HPCN Center at DSI

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Pagina in corso di costruzione *PN -- 22 aprile 1997*

Centro di competenza HPCN

Presentazione

Seleziona qui per una presentazione con SLIDES

1. Introduzione

La Commissione Europea ha avviato una azione specifica per il finanziamento di progetti nell'ambito delle tecnologie **HPCN (High Performance Computing and Networking)**. Rientrano in tale tipologia di proposte applicazioni per le quali le prestazioni del sistema sono raggiunte per mezzo di architetture parallele o distribuite di sistemi a microprocessore: ad esempio, applicazioni nell'ambito biomedico, integrazione di fabbrica, sistemi di controllo distribuiti e/o concorrenti, elaborazione di immagini, basi di dati distribuite, sistemi multimediali, sistemi di tempo reale, etc.

In breve, per HPCN si intende: calcolo e tecnologie di rete ad alte prestazioni, che consentono di ottenere risultati non ottenibili con le tecnologie tradizionali. I sistemi coinvolti vanno dai più costosi mainframe multiprocessore e dalle piattaforme di supercalcolo massivamente parallele fino ai più economici cluster di workstaton e di personal computer. La Commissione Europea intende agevolare l'introduzione della cultura e della tecnologia HPCN presso le piccole e medie industrie, visto che l'avvento di nuove macchine multiprocessore basate sul chip Pentium Pro permette buona potenza di calcolo a prezzi ridotti.

Il bando in questione prende in particolare considerazione studi di fattibilità…e progetti delle aziende che intendono utilizzare tecnologia HPCN per migliorare i loro prodotti o crearne di nuovi. I finanziamenti sono dell'ordine del 50% a fondo perduto. Il bando prevede la costituzione di un consorzio di imprese, non necessariamente a livello internazionale.

2. TTN

Allo scopo di facilitare la presentazione di proposte da parte di imprese la Commissione Europea ha realizzato una rete europea di centri a supporto delle imprese, detti *nodi di trasferimento tecnologico* (Technology Transfer Node, TTN). Uno di questi è il TETRApc, di cui CESVIT fa parte insieme a Pisa Ricerche ed al CSM (Centro Sviluppo Materiali). Riguardo alle attività HPCN del nodo, CESVIT si avvale del supporto scientifico e tecnologico del Dipartimento di Sistemi e Informatica (DSI) dell'Università…degli Studi di Firenze.

3. Attività

Le tipiche attività…di supporto rientrano nell'ambito delle cosiddette *Preparatory Support and Transfer Activities* (PST), nate a complemento dei progetti di ricerca e sviluppo (R&D). Questi ultimi sono destinati ad industrie manifatturiere e/o commerciali che vogliano utilizzare tecnologie HPCN per aumentare la loro competitività, migliorando la qualità delle loro applicazioni e dei loro servizi e riducendo il time to market. A differenza dei progetti R&D, le attività PST hanno l'obiettivo di trasferire e diffondere la tecnologia ed i servizi HPCN in tutti i settori industriali di rilievo, con particolare riguardo alle piccole e medie imprese (PMI o SME che dir si voglia).

Concepite per essere di dimensione più ridotta rispetto ai progetti R&D, le azioni PST devono essere realizzate da consorzi composti da più partner, non necessariamente appartenenti a stati diversi. Il tipico consorzio è generalmente formato da uno o più utenti industriali (fondamentale per la validità del progetto è la presenza di almeno un end-user), uno o più fornitori di competenze tecnologiche (fornitori di applicazioni, tecnologia di calcolo e servizi) e, possibilmente, esperti o centri con competenze relative al dominio di applicazione e/o alla tecnologia HPCN.

Le azioni PST possono essere suddivise in:

- *Stand Alone Assessments* (Studi di fattibilità, task 6.21)
- *Awareness Creation Campaigns Including Assessments* (Promozione di tecnologie HPCN, task 6.22)
- *Demonstration* (Dimostrativi, task 6.23)
- *Best Practice* (task 6.24)

I numeri dei task fanno riferimento al programma Esprit, del quale HPCN costituisce il settore numero 6. I paragrafi successivi passano in rassegna i requisiti delle varie azioni PST.

4. Stand Alone Assessments

Proposte di questo tipo possono essere realizzati da utenti industriali in collaborazione con esperti e/o fornitori di tecnologia. L'utente identifica un processso o un prodotto (economicamente rilevante nei suoi piani finanziari) che possa trarre beneficio dall'uso della tecnologia HPCN. Le attività possono quindi includere: Definizione degli user requirements. Realizzazione di uno studio di fattibilità…sulla conformità…/adattabilità… della tecnologia HPCN agli user requirements. Analisi dei potenziali benefici in termini di crescita delle conoscenze, capacità tecniche, business. Sviluppo di un prototipo sperimentale al fine di confermare la fattibilità dell'applicazione. La durata dell'azione non dovrebbe oltrepassare i 6 mesi, con un effort massimo di 6 persone-mese.

5. Awareness Creation Campaigns Including Assessments

Si tratta di campagne per la diffusione della cultura HPCN, in genere basate sulle cosiddette "storie di successo" (progetti riusciti). Esse hanno lo scopo di promuovere i potenziali benefici derivanti dall'uso della tecnologia HPCN e sono generalmente seguite da una serie di valutazioni di breve durata e limitato volume, realizzate con potenziali utenti industriali. Per azioni di questo tipo la composizione tipica del consorzio è:

- Un'industria ed uno o più centri di competenza, oppure
- Un'associazione di categoria ed un centro di competenza.

La durata dell'azione deve essere contenuta entro un'anno, con un effort da 3 a 6 persone-mese per la campagna di promozione, più al massimo 6 persone-mese per ogni valutazione.

6. Demonstration actions

Sono azioni rivolte a dimostrare i benefici apportati dall'implementazione del calcolo parallelo su applicazioni già esistenti (ad es. mediante porting, adapting), nonché ad illustrare la fattibilità della conversione di prototipi in applicazioni operative o nuovi prodotti (ad es. tramite test sul campo). Una nuova applicazione, o prodotto, posto sul mercato da parte del fornitore di tecnologia, potrà costituire la base per proposte di Best Practice Actions, con nuovi utenti.

Un'azione di questa categoria richiede la presenza di uno studio di fattibilità o di un prototipo dell'applicazione nella quale verrà inserita la tecnologia HPCN. Un'articolazione possibile per il progetto è la seguente:

- Fase 1: porting e/o adattamento dell'applicazione esistente.
- Fase 2: ottimizzazione dell'applicazione.
- Fase 3: test e validazione dell'applicazione finale.

Il consorzio è tipicamente composto da un'industria più uno o più centri di competenza, ed è fondamentale la presenza di uno o più end-user. La durata dell'azione deve essere compresa fra i 3 ed i 18 mesi, con un effort da 6 persone-mese a 4 persone-anno, in dipendenza dall'applicazione e dalla tecnologia.

7. Best Practice Actions

Si tratta di azioni mirate a trasferire ed implementare applicazioni HPCN, già consolidate e testate, su nuove problematiche e/o su nuovi settori industriali. Ciò•può quindi includere una reingegnerizzazione, l'installazione, un test di validazione, la manutenzione ed anche la formazione di personale.

Per azioni di questo tipo il ruolo di fornitore di tecnologia può essere svolto da una grande impresa, oppure (come negli altri task) da uno o più centri di competenza; una piccola o media impresa costituisce l'end-user. Le regole concernenti la durata e l'effort del progetto sono le stesse delle azioni dimostrative.

8. Presentazione di proposte

Nell'ambito dei task descritti il compito dei TTN, e quindi anche di CESVIT e DSI, è inizialmente quello di promuovere la realizzazione di attività PST (contribuendo eventualmente alla loro formulazione) e, successivamente,

- di gestire e coordinare le attività associate al TTN stesso,
- di agire da interfaccia fra le attività PST e la rete di TTN europea nonché la Commissione Europea (CE),
- di disseminare i risultati a livello nazionale (tramite partecipazione a convegni industriali, produzione e distribuzione di materiale pubblicitario, pubblicazione di articoli su riviste e giornali, distribuzione di materiale pubblicitario, pubblicazione di articoli su riviste e giornali, organizzazione di meeting tematici, etc.) ed internazionale,
- di stimolare il trasferimento e l'implementazione della tecnologia HPCN presso nuovi utenti.

La presentazione di proposte può avvenire in qualsiasi momento (presentazione "in continuo"). La commissione esegue tuttavia valutazioni trimestrali dei progetti ad essa pervenuti.

Chiunque sia interessato a presentare un progetto di tipo PST può richiedere un appuntamento ai responsabili del Centro di competenza HPCN, oppure preparare un breve riassunto dell'azione che intende proporre ed inviarlo agli stessi.

- **Responsabile scientifico**

  `Ing. Paolo Nesi`

Dipartimento di Sistemi e Informatica
Facoltà di Ingegneria, Università di Firenze
Via Santa Marta 3
50139 Firenze
Telefono: 055-4796523
Fax: 055-4796363
E-mail: nesi@ingfi1.ing.unifi.it
Utilizzare nesi@dsi.ing.unifi.it per l'invio di file in attach,

- **Responsabile amministrativo**

Ing. Maurizio Campanai
CESVIT (Agenzia per l'alta tecnologia)
Via G. del Pian dei Carpini 28
50127 Firenze
Telefono: 055-4294254
Fax: 055-4284220
E-mail: campanai@cesvit.it campanai@ats.it

Il Centro di competenza mette a disposizione alcuni documenti utili alla formulazione di proposte in ambito HPCN. Questi possono essere scaricati accedendo all'apposita pagina del sito http://aguirre.dsi.unifi.it/~hpcn/; in un'ulteriore pagina è possibile leggere la lista dei progetti presentati dal Centro di competenza e già approvati.

Ritorna alla homepage del Centro di competenza HPCN.

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HPCN Center

Reference People

- **Scientific responsible and Coordinator**

Prof. Ing. Paolo Nesi
Dipartimento di Sistemi e Informatica
Facoltà di Ingegneria, Università di Firenze
Via Santa Marta 3
50139 Firenze
Telefono: 055-4796523
Fax: 055-4796363
E-mail: nesi@ingfi1.ing.unifi.it, nesi@dsi.unifi.it
Utilizzare nesi@dsi.unifi.it for attach files

- **Administrative Responsibile**

Ing. Maurizio Campanai
CESVIT (Agenzia per l'alta tecnologia)
Via G. del Pian dei Carpini, 28
50127 Firenze
Telefono: 055-4294254
Fax: 055-4284220
E-mail: campanai@cesvit.it campanai@ats.it

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HPCN Center at DSI

In this page founded projects from European Commissin are listed. These are related to TETRApc TTN and thus with CESVIT and DSI as HPCN Center. In addition, to these projects other several proposals are under evaluation of Commission.

MOODS ***completed***
Music Object-Oriented Distributed System
Cooperative work and automatic tuning pages in orchestras
MOODS is an innovative idea for automating and managing the large information used by orchestra's during rehearsals and public performance of concerts, operas and ballets. MOODS drastically reduces the time needed for modifying main scores and music parts of at least the 20%, and address the automatic tuning pages during executions.

ICCOC ***completed***
Integrating CAD/CAM Operations into CNC-based machines
ICCOC project has demonstrated the possibility of integration of CAD/CAM functionality on CNC-based machines by means of HPCN technology. The integration of CAD/CAM allows the reduction of costs related to non-planned CAD/CAM activities of at least 35 %.

MUPAAC ***completed***
Multi Processor Architecture for Automatic Control
Flexible Multiprocessor system for pipeline of Production
MUPAAC project has reduced of 23 % the costs of controllers for the machine builders. This will be obtained by passing from a simple dual processor architecture to a flexible multiprocessor architecture with the introduction of HPCN.

IMEASY ***completed***
Integrated Multiprocessor Expadable Audio Spatialisation System
Multichannel sound system for live events
IMEASY allows the definition of spatial sound effects in real time, reducing of cost of about 30% with respect to manual and/or hardware solutions. IMEASY is mandatory for live events, theatre and entertainment parks as the exact timing of spatial effects may be dependant on external events and for this reason decided only during the performance.

For others related projects please visit the www page of Coordinator Paolo Nesi

Link to the Machinery group of TTN HPCN.
Link to the Media-Video-Entertainment of TTN HPCN.

Return to the home page of the HPCN Center at DSI.

PN -- 31 Aug. 1998

Centro di competenza HPCN

Documentazione

Presso il Centro di competenza sono disponibili i documenti della Comunità Europea relativi ad HPCN ed altri testi utili per la formulazione di proposte. I primi sono tratti dal sito **CORDIS** (COmmunity Research and Development Information Service, indirizzo: www.cordis.lu), il quale ospita molte pagine specifiche per HPCN (www.cordis.lu/esprit/src/hpcnhome.htm).

I documenti elencati possono essere scaricati premendo sulle rispettive voci. Ogni documento è disponibile sia in formato *Word 6* che *Postscript*; il metodo di compressione impiegato è *ZIP*.

- **Programma di lavoro di Esprit**
  Il documento, scritto in lingua italiana, presenta il programma del progetto Esprit per l'anno 1997. Sono descritti i vari "domìni" del progetto, fra i quali rientra HPCN (è il numero 6).
  Formato Word 6
  Formato Postscript

- **Esprit: An Introduction for Proposers**
  Questo documento completa il precedente per quanto riguarda la formulazione di proposte; esso fornisce un'introduzione non specifica per HPCN, ma generica per Esprit.
  Formato Word 6
  Formato Postscript

- **HPCN PST Activities**
  Si tratta di una descrizione delle attività PST (Preparatory, Support and Transfer) relative al dominio HPCN. Il documento contiene anche i *form* per le proposte.
  Formato Word 6
  Formato Postscript

- **Schema di proposta**
  Questo documento presenta la traccia di una proposta tipica nell'ambito *Technology Transfer* di HPCN, ed è utile per ricavare le linee guida per la stesura. Sono chiaramente evidenziate le parti che possono essere riutilizzate nella formulazione di una nuova proposta.
  Formato Word 6
  Formato Postscript

- **Contratto ed allegati**
  I file ZIP contengono tre documenti: *ass-cont* è il testo del contratto che viene stipulato fra la Comunità ed i partner del consorzio alla partenza di un progetto; *ass-ann2* ed *ass-ann3* sono due allegati.
  Formato Word 6
  Formato Postscript

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HPCN: High Performance Computing and Networking

12/6/97

[Fare clic qui per iniziare]

Sommario

Autore:Paolo Nesi

Posta elettronica: nesi@ingfi1.ing.unifi.it

Home Page: http://www.dsi.unifi.it/~nesi/

Project MOODS Music Object Oriented Distributed System

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Project ICCOC Integrating CAD/CAM Operations into CNC-Based Machines

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Diapositiva di PowerPoint

Project MUPAAC Multi Processor Architecture For Automatic Control

Diapositiva di PowerPoint

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ICCOC

Integrated CAD/CAM Operations into CNC-based machines

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- [Industrial benefits]
- [Success Story]
- [Press Release]

The ICCOC Project

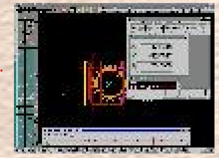
- [Objectives]
- [Executive Summary]
- [State of the Art]
- [The Approach]
- [Results]
- [Conclusions]
- [Partners]
- [Contact Person]
- [The TTN]

An activty with TETRApc TTN, ESPRIT IV HPCN

visitors

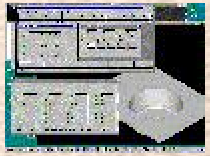
ICCOC

All in a click

*"Using **ICCOC**, CNC user can access directly Unix CAD/CAM application from Windows NT CNC console, thus **saving 60% of time** for Re-CAD and Re-CAM operations. We have **improved the productivity of 20%**"*

Massimo Giorgetti - **TECMA S.r.l.**




*"Con **ICCOC**, gli operatori delle macchine a controllo numerico possono utilizzare direttamente sulla console Windows NT del CNC le applicazioni CAD e CAM Unix, **diminuendo del 60% il tempo necessario** per le operazioni di Re-CAD e Re-CAM. Abbiamo **aumentato la produttività del 20%**"*

Massimo Giorgetti - **TECMA S.r.l.**

- ***Dead time reduction of about 60%***
- ***How to improve productivity of about 20%***
- ***Requalification of CNC operators***

The other pages of this site are available in *English* only

- ***Eliminare il 60% dei tempi morti***
- ***Come aumentare la produttività della vostra azienda del 20%***
- ***Riqualificare gli operatori CNC***

Le altre pagine di questo sito sono disponibili *solo in inglese*

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

MUlti Processor Architecture for Automatic Control

- Main Page
- Industrial Benefits
- Success Story

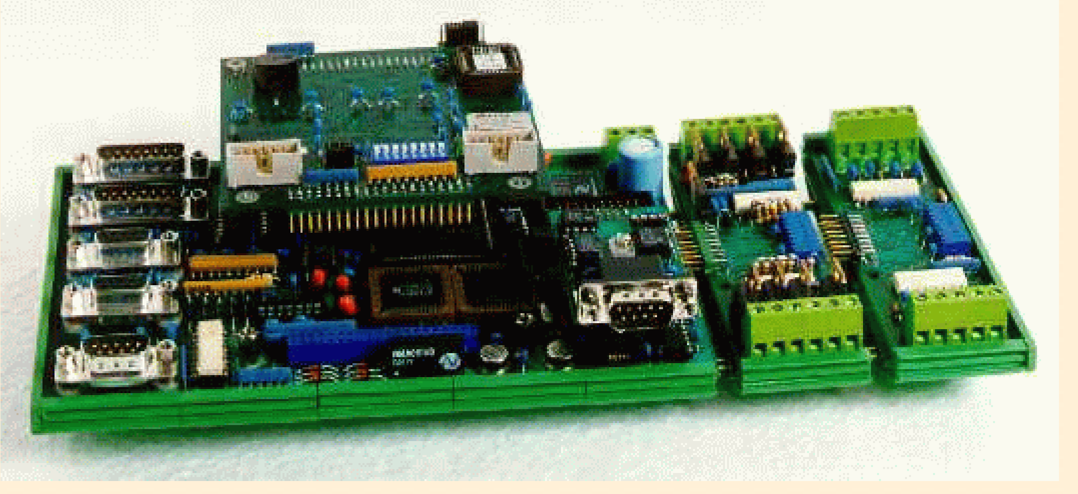
The MUPAAC Project

- General Background
- Market Situation
- State of the Art
- General Architecture
- Components
- Flexibility
- Planned Results
- Dissemination
- Partners
- Contact Person
- The TTN
- Related Web Sites
- Bibliography

TETRApc HPCN ESPRIT Project n.26418

MUPAAC project consists in improving capabilities of an already present architecture for automatic control for industrial machines. It will make possible to reach performance better or comparable to the best which can be found in the market of automatic controllers at lower cost.
The targeted end users are builders of automatic machine tool (for cutting, soldering, moving, electron erosion, etc.) which can be used in pipelines of production. Main objectives and results of MUPAAC are:

- **the adoption of HPCN technology for making performance of microprocessor based controllers of SED comparable or better with respect to the best which are available on the market, but at a lower cost/price for the machine builders. An increment of functionality is also planned;**
- **introducing HPCN technology for obtaining, on the basis of already available computerized control of SED a flexible and reconfigurable parallel/distributed system for control in order to reduce the costs/prices for the machine builders of about 20 %. The system has been considered strongly needed for integrating automatic machines into pipelines of production;**
- **the deployment of HPCN technology for improving performance and decreasing of cost of products and thus for covering a wider market;**
- **the dissemination of results at National and European levels.**



I'M EASY

Audio Processing and Sound Spatialization effects in Real-time

Integrated Multiprocessor Expandable Audio Spatialization System

I'M EASY

An activity within TETRApc TTN, ESPRIT IV HPCN

I'M EASY is an interactive and easy to use system to simulate and produce spatial effects in real-time, saving up to 30% of the costs of a manual and/or hardware solution. I'M EASY fills a gap in the current commercial market, as it provides a device for *creating in real-time* original spatialisation efects that cannot be preencoded or prerecorded, and need to be created during the performance of live events, theater applications, interactive museum shows and entertainment parks.

Pro Audio Professionals involved in audio and multimedia installations, post-production services, and in the field of entertainment activities, including game parks, theater and outdoor events can benefit from I'M EASY audio spatialisation system.

To carry out these services, a prototype will be implemented.

Features

- Audio processing and spatialisation system
- Highly interconnected parallel network of digital signal processor (DSP)
- Advanced control of multi-channel sound
- Creation of spatialisation effects applied to external signals in real-time
- Scalable and re-configurable

I'M EASY è un sistema facile di usare ed interattivo per simulare e produrre effetti di spazializzazione in tempo reale, diminuendo del 30% dei costi di una soluzione manuale e/o hardware. I'M EASY riempie una mancanza nel mercato commerciale, offrendo un dispositivo per *creare in tempo reale* effetti originali di spazializzazione che non possono essere precodificati o preregistrati, e richiedono di essere creati durante la prestazione di spettacoli al vivo, applicazioni di teatro, mostre interattive di musei, e parchi d'intrattenimento.

I professionali nel settore Pro Audio di installazioni audio e multimedia, servizi di post produzione e nelle attività di intrattenimento, includendo parchi di gioco, teatri ed eventi all'aperto, possono trarre beneficio dal sistema di spazializzazione audio I'M EASY.

Per realizzare questi servizi, un prototipo sarà realizzato.

Caratteristiche

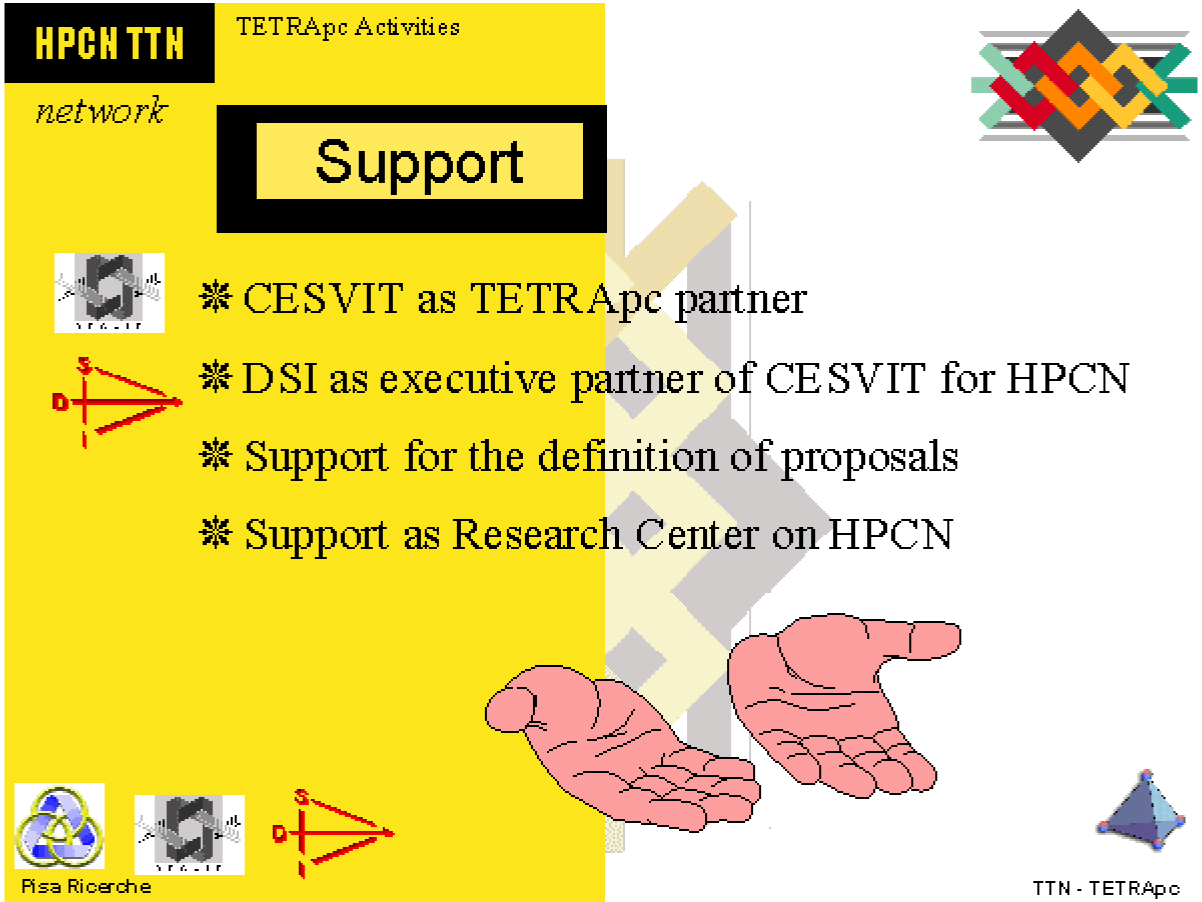
- Sistema di spazializzazione e processamento di audio
- Rete parallela di processori di segnali digitali (DSP)
- Controllo avanzato di suono multicanale
- Creazione di effetti di spazializzazione applicati a segnali esterni in tempo reale
- Scalabile e riconfigurabile

[HPCN Center at DSI]

Last Updated September 1, 1999

Ultimo aggiornamento 1 Settembre 1999


HPCN TTN
network
TETRApc Activities
HPCN: High Performance Computing and Networking
Dr. Ing. Paolo Nesi
DSI, Dipartimento di Sistemi e Informatica
Universita' degli Studi di Firenze
nesi@dsi.ing.unifi.it
http://www.dsi.unifi.it/~nesi
Pisa Ricerche
TTN - TETRApc



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HPCN TTN network

TETRApc Activities

Possibilita' di Finanziamento

- Grande richiesta di progetti HPCN
- finaziamento 50% o 100% costi marginali
- SME: <500 dip. or <50 MECU
- Realizzazione di full project HPCN
- Realizzazione di progetti con il supporto di un TTN

Pisa Ricerche

TTN - TETRApc

HPCN TTN
network

TETRApc Activities

HPCN Technology

- Distributed Systems
- Parallel Architectures
- High Performance Workstations
- Clusters of Machines
- Etherogeneus Architectures
- Internet and Intranet
- Real Time Systems
- .....

Pisa Ricerche

TTN - TETRApc

HPCN TTN

network

TETRApc Activities

HPCN: Application Fields

- Factory Integration, CIM
- Systems of Control: HW-SW
- Embedded Systems: HW-SW
- Wide/Local Area Network: HW-SW
- Image Processing, Comp. Vision: HW-SW
- High Performance Networks: HW-SW
- Electro-Medicals: HW-SW
- Electro-Musicals: HW-SW
- ....

Pisa Ricerche

TTN - TETRApc

HPCN TTN network

TETRApc Activities

Integration In Manufacturing, CIM

- Integration CAD/CAM and machines areas
- Parallelisation of Algorithms
- Multi-microP, Embedded
  - ➔Remoting and improving CAD/CAM
  - ➔Defect Detection
  - ➔Control of production
  - ➔Simulation
  - ➔.......

Pisa Ricerche

TTN - TETRApc

HPCN TTN network

TETRApc Activities

Medicale

- ◆ Distrib. di Applicazioni/Servizi, WAN
- ◆ Parallelizzazione di algoritmi
- → Elaborazione di immagini
- → Ricostruzione e manipolazione solidi
- → Simulazione comportamento protesi
- → Simulazione comport. tessuti umani
- → Supporto in Sala Operatoria
- → ....

Pisa Ricerche

TTN - TETRApc

HPCN TTN network

TETRApc Activities

Multimedia

- Parallelizz. di algoritmi di conversione
- Distribuzione, virtualizzazione di servizi
- → Editor/servizi cooperativi/distribuiti
- → Virtualizzazione di basi di dati
- → Sistemi di conversione
- → Simulazione 2D, 3D, 4D
- → Virtual Reality
- → ....

Pisa Ricerche

TTN - TETRApc

HPCN TTN

network

TETRApc Activities

Sensoristica

- ◆ Sistemi Embedded e Multiproc
- ◆ Parallelizzazione Algoritmi
- → Detection di difetti
- → Monitoraggio per controllo ambientale
- → Misure in Tempo Reale su pazienti
- → Interfacce Utente/Supporti per Disabili
- → ....

Pisa Ricerche

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network

TETRApc Activities

Embedded Systems, HW-SW

- Multi-processor architecture
- Concurrent Systems
- Reliable Distributed Systems
- Real Time Systems
  - →Optimisation of Algorithms,
  - →Scheduling Task
  - →Performance Improvement
  - →.........

Pisa Ricerche

TTN - TETRApc

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HPCN TTN network

TETRApc Activities

Computer Vision and Image Processing

- Motion Analysis: measures, recognition
- Counting moving objects
- Detection of Cavity Conditions
- Defect Detection
- Measures, Control of Flows: turbine, water, etc.
- ASIC, VLSI, PGA
- Special Purpose Architectures
- ....

Pisa Ricerche

TTN - TETRApc

HPCN TTN

network

TETRApc Activities

Objectives of HPCN Domain

Facilitare l'adozione di tecnologie HPCN per

- → incrementare prestazioni
- → migliori e nuove funzionalita'
- → distribuire servizi
- → disseminare tali tecnologie
- → dimostrare le potenzialita' delle tecnologie

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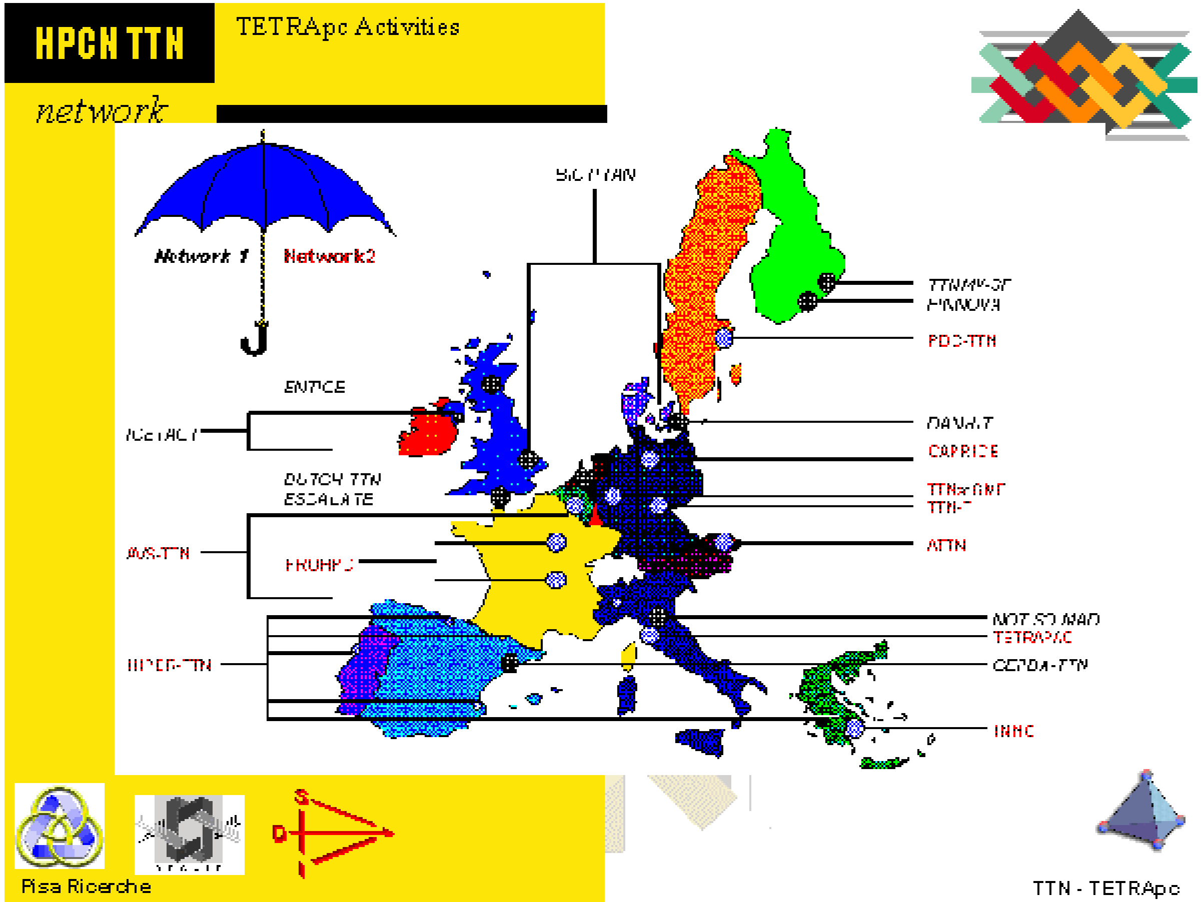
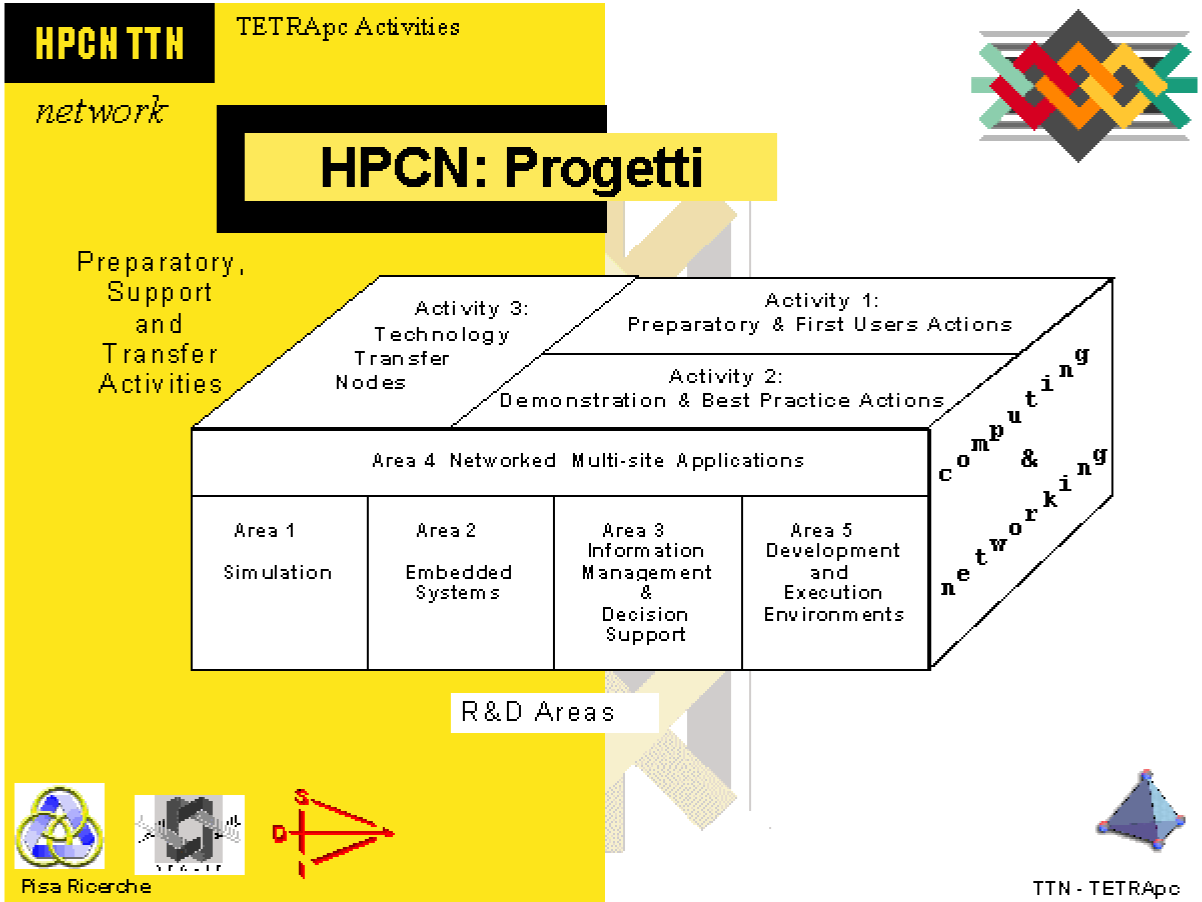
Diapositiva 13 di 56



Diapositiva 14 di 56



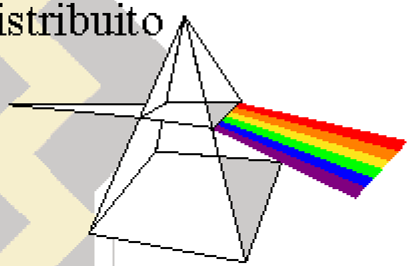
Diapositiva 15 di 56

HPCN TTN
network

TETRApc Activities

HPCN: Progetti

- per es.: da mono a multiprocessore
- per es.: da standalone a distribuito
- Parallelizzare
- distribuire



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HPCN TTN network

TETRApc Activities

HPCN: Progetti

- chiari benefici per l'end-user e per l'industria
- motivazioni: quantitative e qualitative
- disseminazione nazionale e internazionale
- controllo quantitativo del progetto

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HPCN TTN

TETRApc Activities

network

Progetti Supportati dal TTN

- ➔Presentazione di progetti in continuo
- ➔Progetti preparatori
- ➔Progetti di diffusione della tecnologia
- ➔Progetti di trasferimento tecnologico
- ➔Progetti di rivalutazione
- ➔Consorzio non internazionale

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HPCN TTN network

TETRApc Activities

Tipologie di Progetti

- task 6.21: Studi di Fattibilita'
- task 6.22: Promozione di Tecnologie HPCN
- task 6.23: Dimostrativi
- task 6.24: Best Practice

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HPCN TTN

network

TETRApc Activities

Preparatory & First User Action

- ➔Valutare i vantaggi dell'HPCN
- ➔Diffondere l'HPCN
- ➔Facilitare l'uso di tecnologie HPCN
- ➔Rendere i prodotti piu' competitivi
- ➔....

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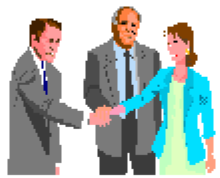
HPCN TTN
network

TETRApc Activities

Studi di Fattibilita' (task 6.21)

- Industria e Centro(i) di competenza
- End-User (anche meglio)
- Industria come First User



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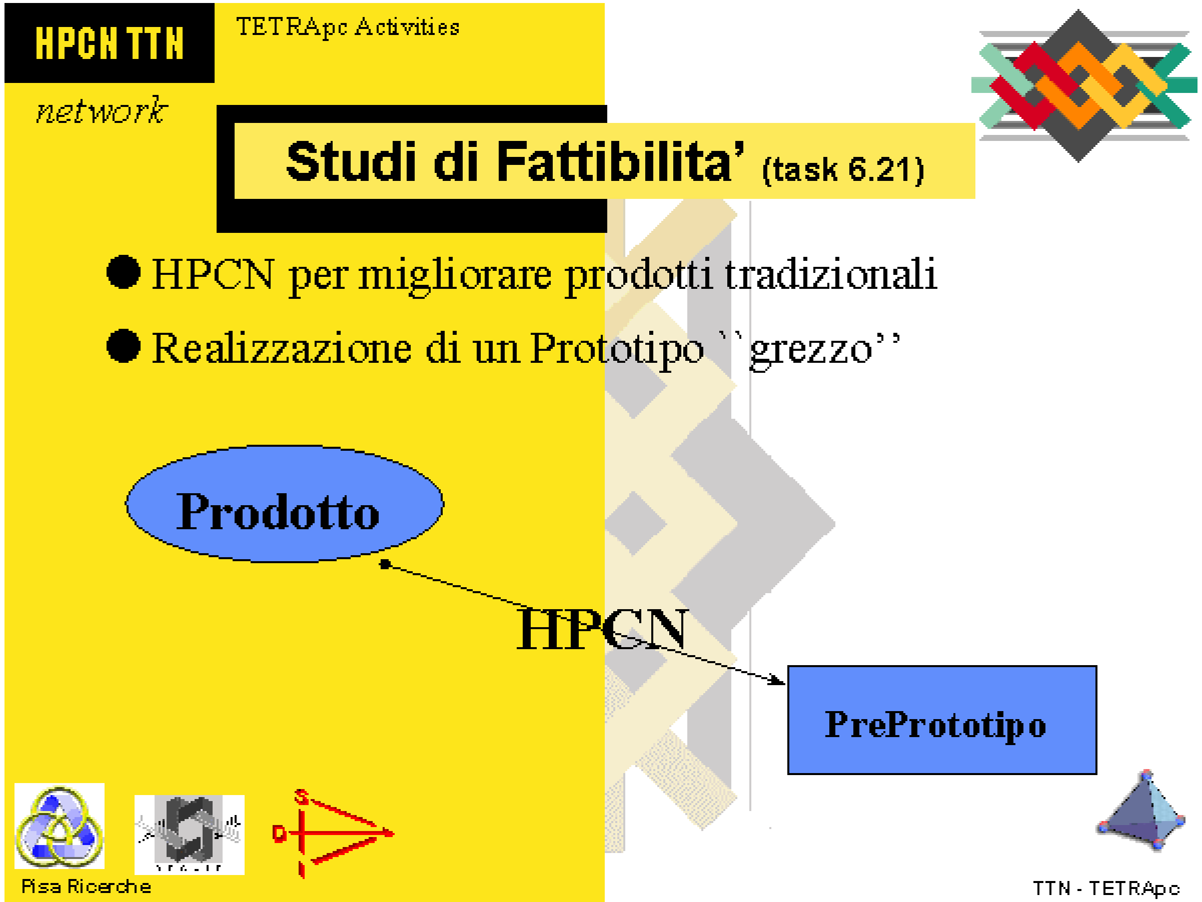
TTN - TETRApc

Diapositiva 21 di 56



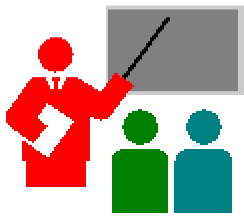
Diapositiva 22 di 56

HPCN TTN
network

TETRApc Activities

Promozione di Tec. HPCN
(task6.22)

- es: Industria e Centro(i) di competenza
- es: Assoc. di Categoria e Centro di competenza
- Diffusione di Tecnologie HPCN
- Valutazione dei ritorni



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Diapositiva 24 di 56

Diapositiva 25 di 56

HPCN TTN network

TETRApc Activities

Best Practice (task 6.24)

- Industria e Centro(i) di competenza, o
- SME + grossa industria (technology provider)
- Uno of piu' ``End-User''

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HPCN TTN network

TETRApc Activities

Best Practice (task 6.24)

- Presenza di un prodotto HPCN
- HPCN per migrare/re-ingegnerizzare prodotti

→istallation
→testing
→validation
→maintenance
→training

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Dimensioni dei Progetti

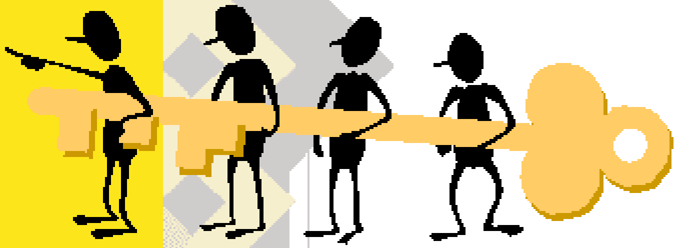
- Task 6.21
  → Durata: 6 mesi, Lavoro: 6 mesi/uomo
- Task 6.22
  → Durata: 12 mesi, Lavoro: 6+6 mesi/uomo
- Task 6.23 e 6.24
  → Durata: 18 mesi, Lavoro: 4 anni/uomo

HPCN TTN
network

TETRApc Activities

Il Consorzio

- Anche solo composto da Italiani
- Industria(e) + Centro(i) + [End-User(s)]
- Industria(e) + Tech.Provider(s) +[end-user(s)]
- Bilanciato
- Motivato
- Competente
- Affidabile



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Diapositiva 29 di 56

Diapositiva 30 di 56

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TETRApc Activities

La Parte Finanziaria

- Consuntivo Economico
- Form da compilare
- Lettere di Adesione al Consorzio

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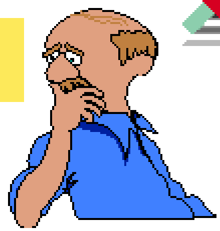
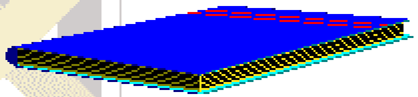
TETRApc Activities

La Parte Tecnica



- Why: Perche' ve ne e' necessita'?
- What: Cosa verra' proddotto?
- Who: Chi eseguira' il lavoro?
- How: Come verra' eseguito?



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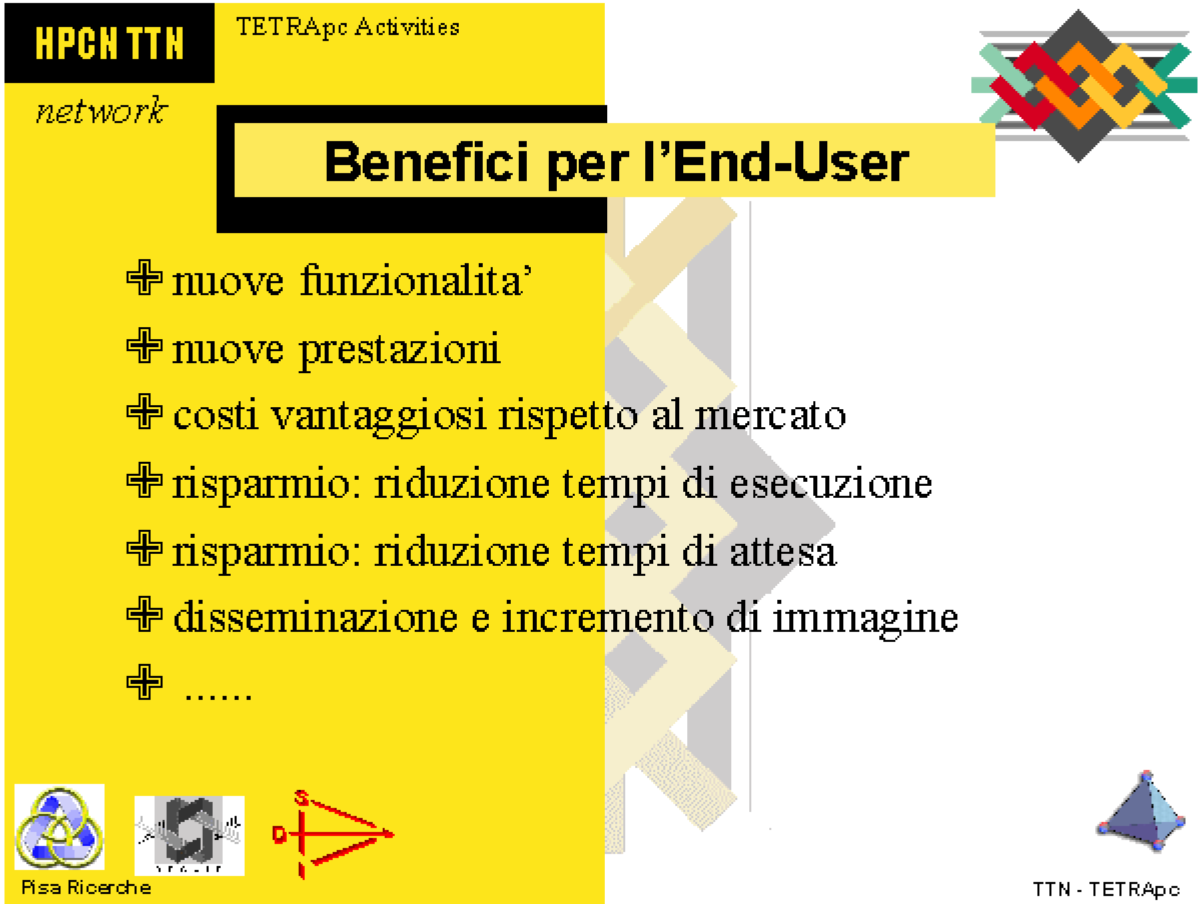
Diapositiva 33 di 56



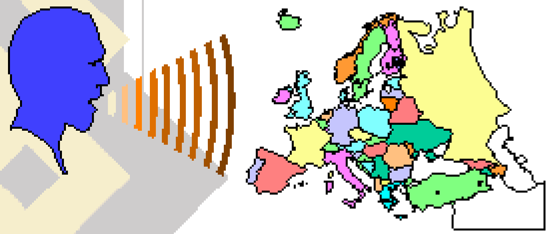
Diapositiva 34 di 56

HPCN TTN network

TETRApc Activities

Disseminazione Risultati

- Nazionale e a livello Europeo
- Partecipazione a fiere
- Partecipazione a congressi
- Pubblicazione di articoli
- Organizzazione di Dimostrazioni Pubbliche



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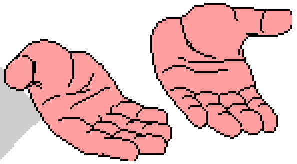
network

TETRApc Activities

Our Support

- Identification of Proposal Area
- Identification of Proposal Task
- Support for:
  - Partners Collection
  - Definition of the Team
  - Implementation of the Proposal



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Diapositiva 36 di 56

HPCN TTN network

TETRApc Activities

References

Ing. Paolo Nesi
DSI, Dip. di Sistemi e Inform.
Facolta' di Ingegneria
Via S. Marta, 3
50139 Firenze
Tel: 055-4796523
Fax: 055-4796363
email: nesi@dsi.ing.unifi.it
http://aguirre.dsi.unifi.it/~hpcn

Ing. Maurizio Campanai
CESVIT (High Tech Agency)
Fortezza da Basso
Via Pian dei Carpini, 28
50127 Firenze
Tel: 055-42941
Fax: 055-4294220
email: campanai@cesvit.it
http://www.cesvit.it/

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TETRApc Activities

Approved Proposals

- MOODS
- ICCOC
- MUPAAC
- ASPECT
- MASC

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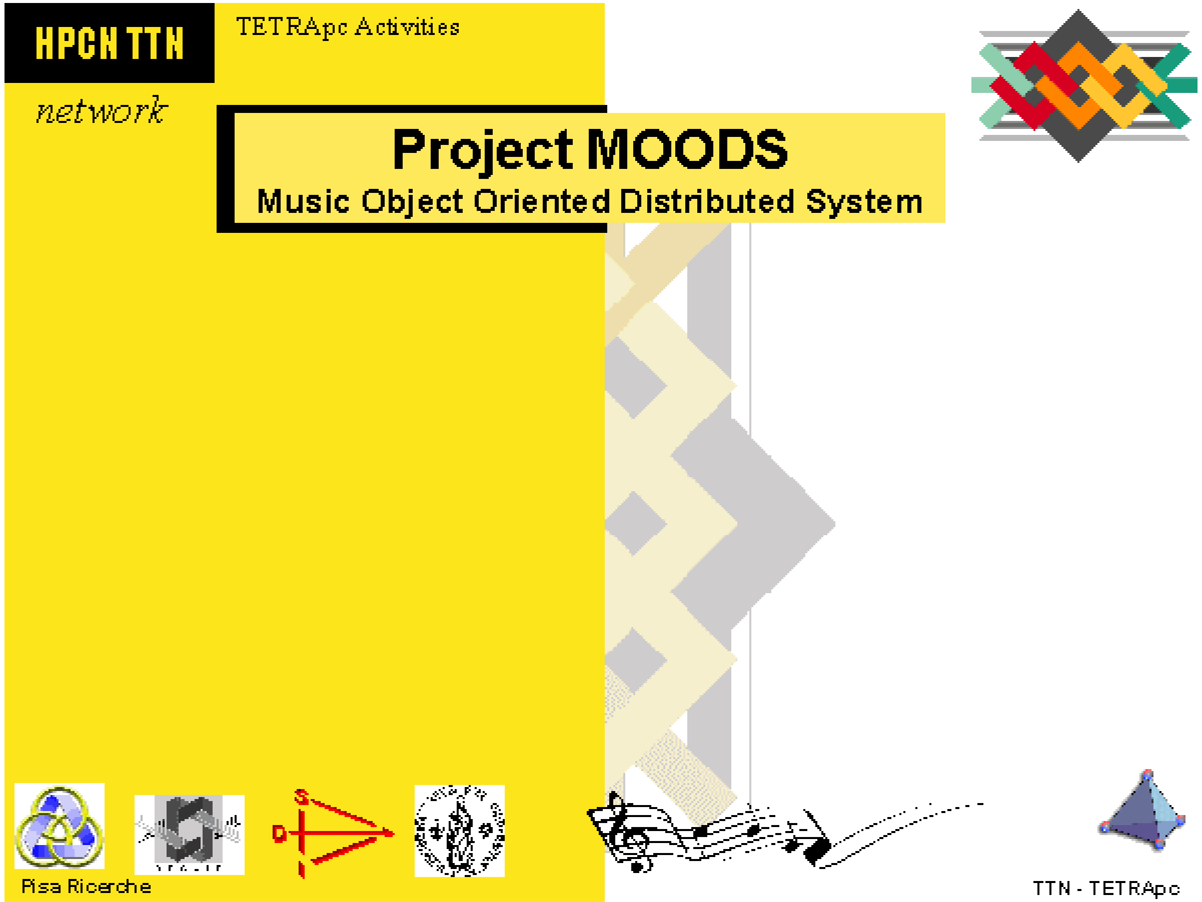
HPCN TTN
network
TETRApc Activities
Project MOODS
Music Object Oriented Distributed System
Pisa Ricerche
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network

TETRApc Activities

Project MOODS

Music Object Oriented Distributed System

- ✦ Reduction of time for modifications
- ✦ Reduction of time in rehearsals
- ✦ Saving of interpretation/instrumental information
- ✦ Automatic, centralised Turning of Page
- ✦ Demonstration & Dissemination
- ✦ Network 100VG, embedded, LINUX,......
- ✦ ...... advanced prototype.

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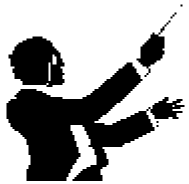
TETRApc Activities

Project MOODS

Music Object Oriented Distributed System

- Task 6.23
- Cooperative Editor of Scores
- Substitution of paper in orchestras
- Integration with the archive of scores
  - from Stand-Alone to Distributed
  - New application field
  - New products
  - New market



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TETRApc Activities

Project MOODS

Music Object Oriented Distributed System

- **DSI**, Dip. Sist. e Inf., Univ. FI (tech.prov), PC
- **Teatro Alla Scala** (end-user), Theatre
- **BMG Ricordi** (end-user), Publisher
- **Scuola di Musica di Fiesole** (end-user),
- **ELSEL** (tech.consumer), Industrial Firm
- **Shylock** (tech.provider), Distributed Databases of Music

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TETRApc Activities

Project MOODS

Music Object Oriented Distributed System

- Project Coordinator: DSI (Paolo Nesi)
- Task: 6.23 (demonstration)
- Start: 15 July 1997
- Duration: about 1 year
- Total Costs: 497809 ECUs
- Total Funding: 248904 ECUs (50%)
- Man/year: 3.87

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TETRApc Activities

Project MOODS

Music Object Oriented Distributed System

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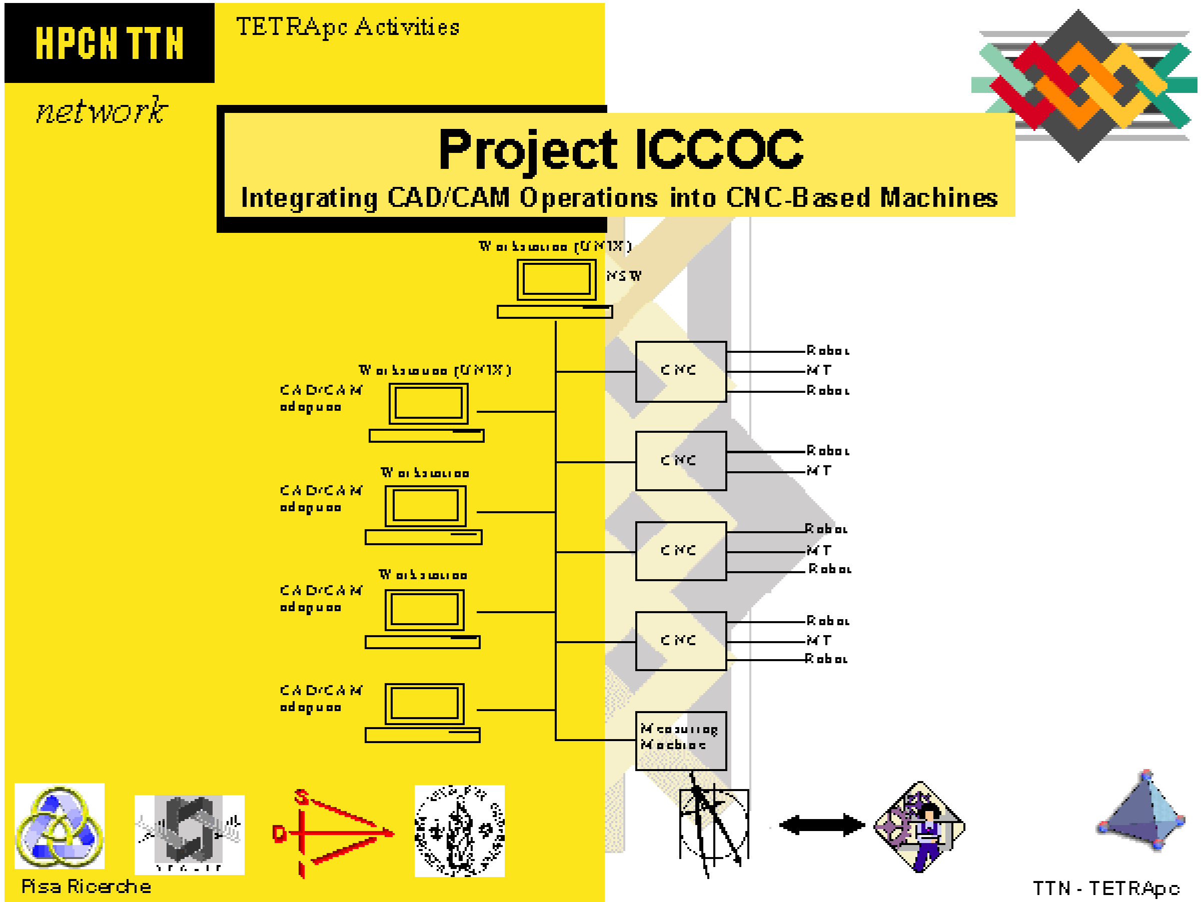

Diapositiva 45 di 56

HPCN TTN

network

TETRApc Activities

Project ICCOC

Integrating CAD/CAM Operations into CNC-Based Machines

- Reduction of times for changes in CAM
- Reduction of times for validating pieces
- Optimisation of production costs
- Integration of the factory
- Network Monitoring
- Demonstration & Dissemination
- Network, Windows NT......
- ...... early prototype

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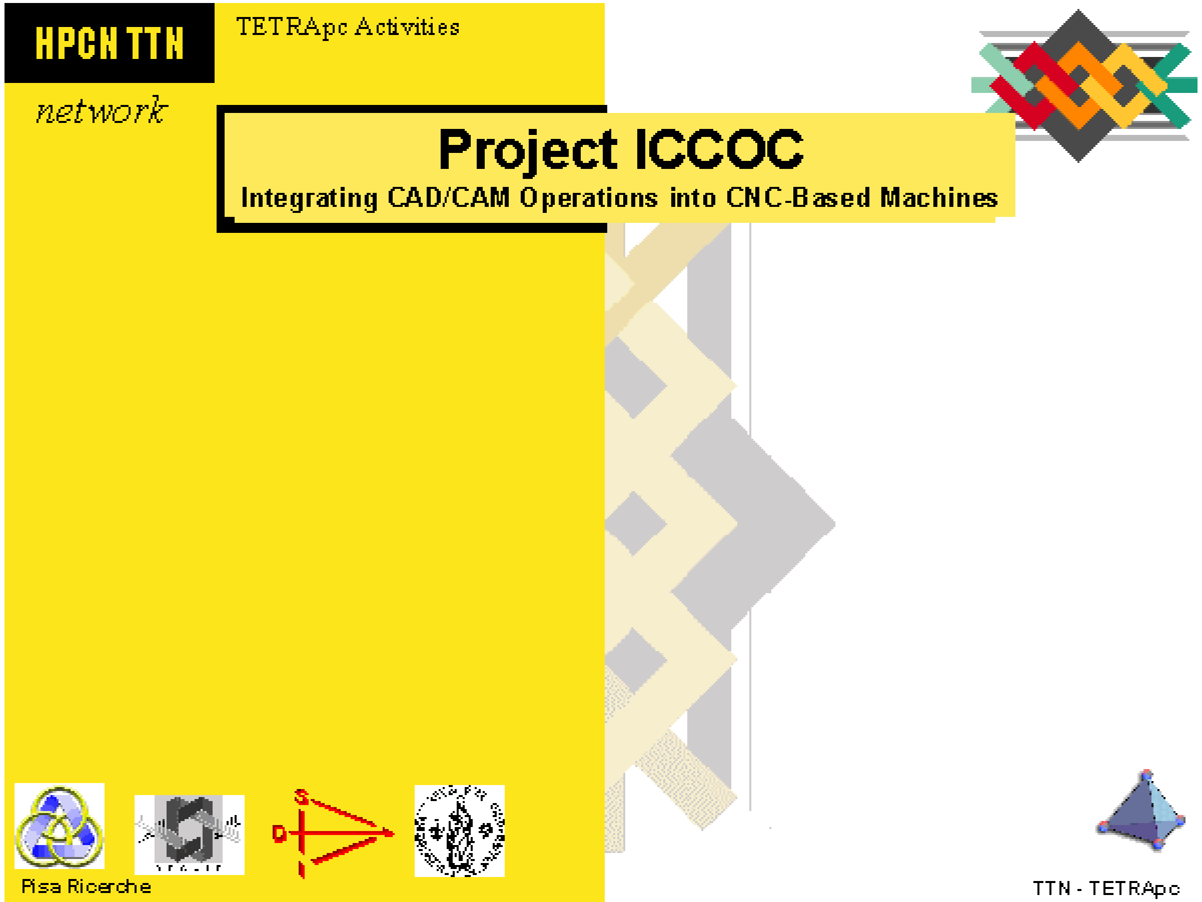
HPCN TTN
network
TETRApc Activities
Project ICCOC
Integrating CAD/CAM Operations into CNC-Based Machines
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HPCN TTN

network

TETRApc Activities

Project ICCOC

Integrating CAD/CAM Operations into CNC-Based Machines

Definition of Main Requirements

- Remoting CAD/CAM on CNC for modifications in real-time
- Executing CAM on the based of CNC details (geometry, tools, etc.)
- Generating/Modify Measure Sections on CNC
- Supervising Milling Machines Area (MM + Robots)
- Optimizing resources of both CAD/CAM and CNC areas, network management (Computer, machines, pieces, etc.)
- Fast access to data from CNC into CAD and CAM databases
- ....

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network

TETRApc Activities

Project ICCOC

Integrating CAD/CAM Operations into CNC-Based Machines

- Task 6.21
- Remote execution of CAD/CAM on MT
- Dynamic Optimisation of Resources
- Reliable data transfer
  - ↑from Stand-Alone to Distributed
  - ↑New functionalities
  - ↑New Product
  - ↑Increment of Market

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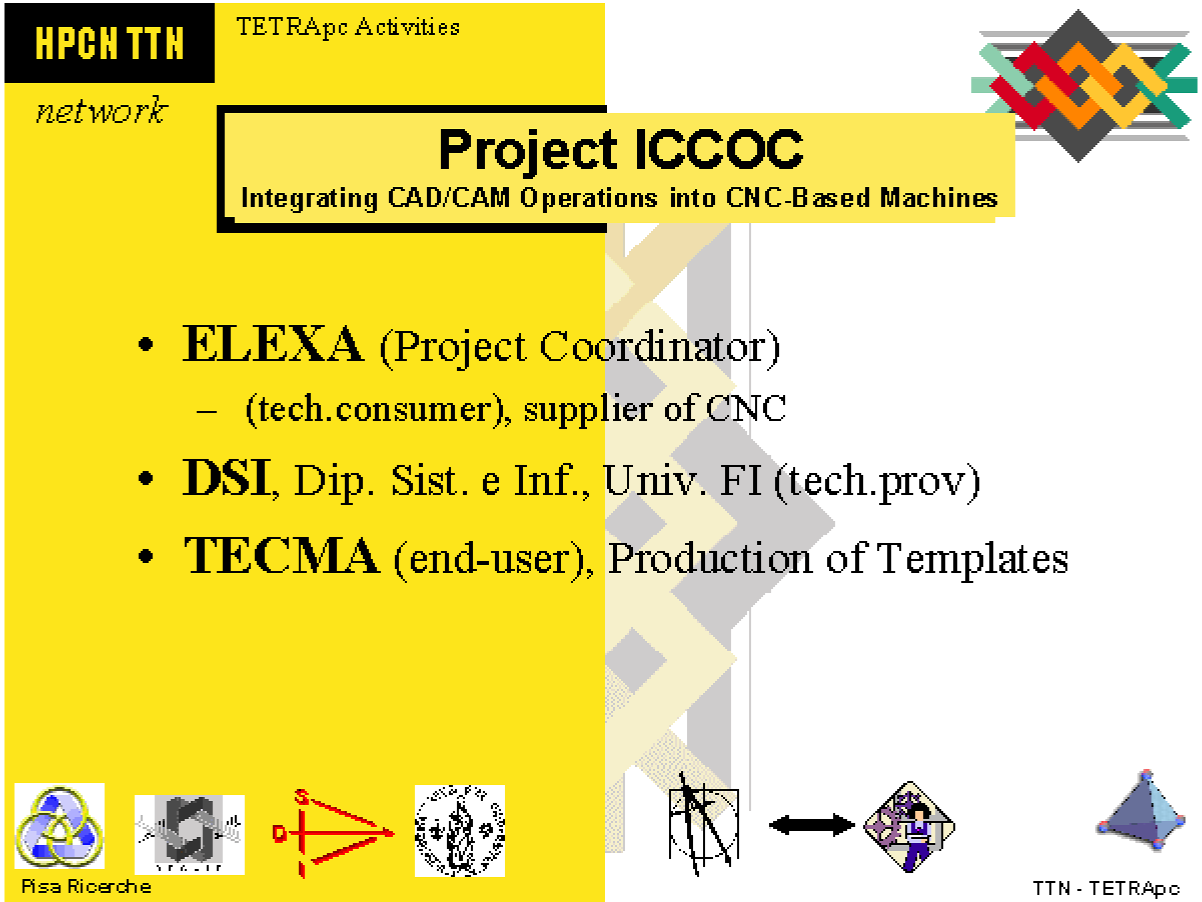

Diapositiva 50 di 56

HPCN TTN network

TETRApc Activities

Project ICCOC

Integrating CAD/CAM Operations into CNC-Based Machines

- Project Coord.: ELEXA (Marco Perfetti)
- Task: 6.21 (early study)
- Start: 15 July 1997
- Duration: 6 months
- Total Costs: 58310 ECUs
- Total Funding: 29155 ECUs (50%)
- Man/year: 0.631

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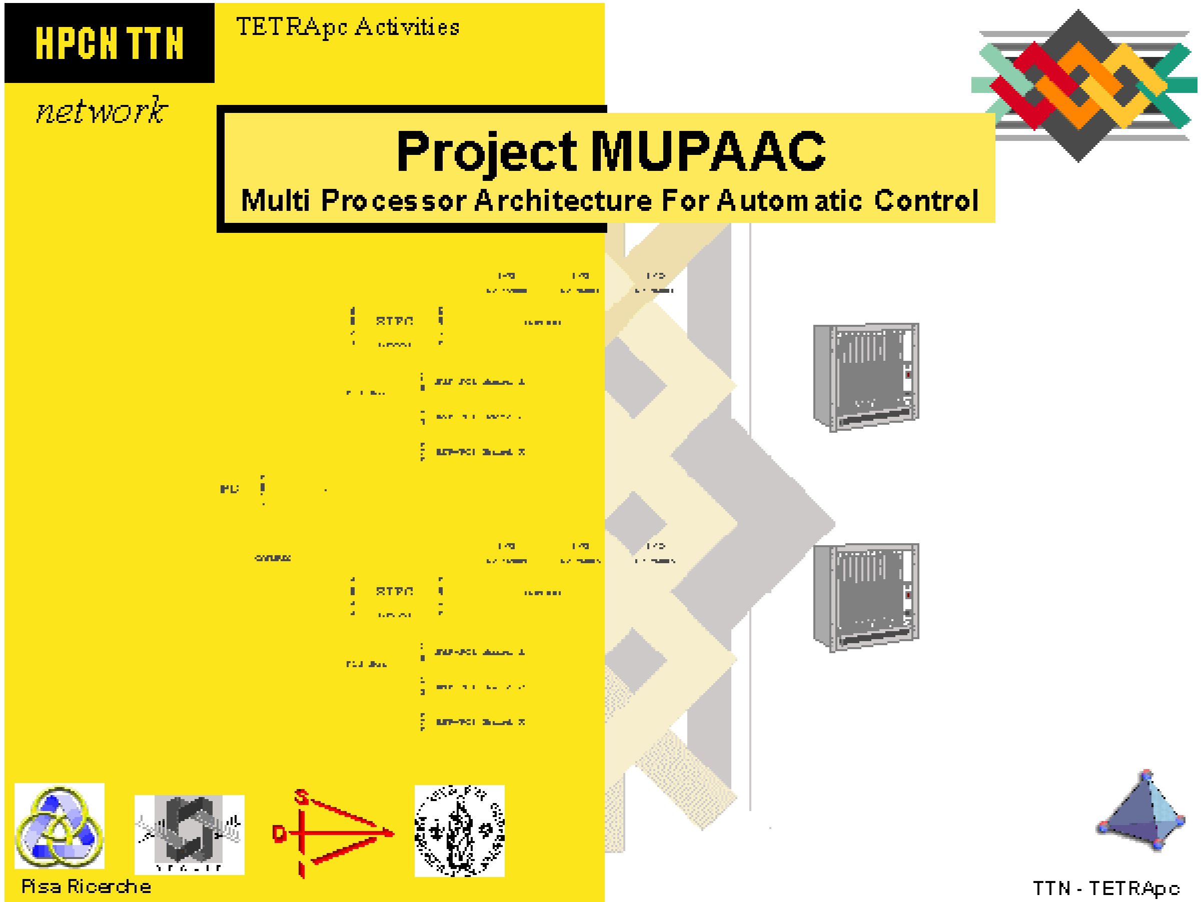
HPCN TTN
network
TETRApc Activities
Project MUPAAC
Multi Processor Architecture For Automatic Control
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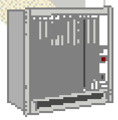
TETRApc Activities

Project MUPAAC

Multi Processor Architecture For Automatic Control

- Cost/Price Reduction for Control Systems
- Scalability of Control Systems
- Open Arch. for Factory Integration
- Demonstration and Dissemination
- Integrated System for Producing passpartout
- PCI, CANbus, ...
- ......prototype



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TETRApc Activities

Project MUPAAC

Multi Processor Architecture For Automatic Control

- DEMONSTRATION, 6.23
- From Dual-Processor to Multi-Processor
- Configuration Flexibility
- System Integrability
- From Low to Med-performance
  - ↑New functionalities
  - ↑Increment of the market

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TETRApc Activities

Project MUPAAC

Multi Processor Architecture For Automatic Control

- **SED** (PC) (Tech.consumer), CNC builder
- **DSI**, Dip. Sist. e Inf., Univ. FI (tech.prov), HPCN architecture and HW-SW
- **VALIANI** (end-user), Passpartout Builder
- **CESVIT** (tech. prov.)
- **DIE**, Dip. Ing. Elettronica (tech.prov.), ASIC

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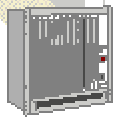

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HPCN TTN network

TETRApc Activities

Project MUPAAC

Multi Processor Architecture For Automatic Control

- Project Coordinator: SED (Carlo Bruni)
- Task: 6.23 (demonstration)
- Start: to be received
- Duration: 1 year
- Total Costs: 428750 ECUs
- Total Funding: 214375 ECUs (50%)
- Man/ years: 3.86

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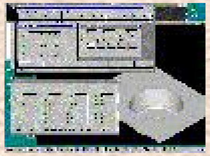
ICCOC

All in a click


*"Using **ICCOC**, CNC user can access directly Unix CAD/CAM application from Windows NT CNC console, thus **saving 60% of time** for Re-CAD and Re-CAM operations. We have **improved the productivity of 20%**"*

Massimo Giorgetti - **TECMA S.r.l.**




*"Con **ICCOC**, gli operatori delle macchine a controllo numerico possono utilizzare direttamente sulla console Windows NT del CNC le applicazioni CAD e CAM Unix, **diminuendo del 60% il tempo necessario** per le operazioni di Re-CAD e Re-CAM. Abbiamo **aumentato la produttività del 20%**"*

Massimo Giorgetti - **TECMA S.r.l.**

- ***Dead time reduction of about 60%***
- ***How to improve productivity of about 20%***
- ***Requalification of CNC operators***

- ***Eliminare il 60% dei tempi morti***
- ***Come aumentare la produttività della vostra azienda del 20%***
- ***Riqualificare gli operatori CNC***

The other pages of this site are available in *English* only

Le altre pagine di questo sito sono disponibili *solo in inglese*

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

60% Dead Time Reduction

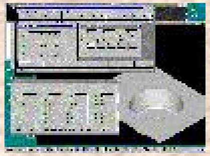
60% Dead Time Reduction

Some examples taken from companies needs follows:

All the time that your employers uses going around to carry paper, electronics supports and ask modifications to other employers are dead times for your company !!!

With ICCOC you can use CAD and CAM directly on the Elexa CNC console and, therefore, all the necessary modification can be performed without moving from the work place.

UNIX CAD in an NT CNC Console. Click to see a more detailed image (**43 Kb**)

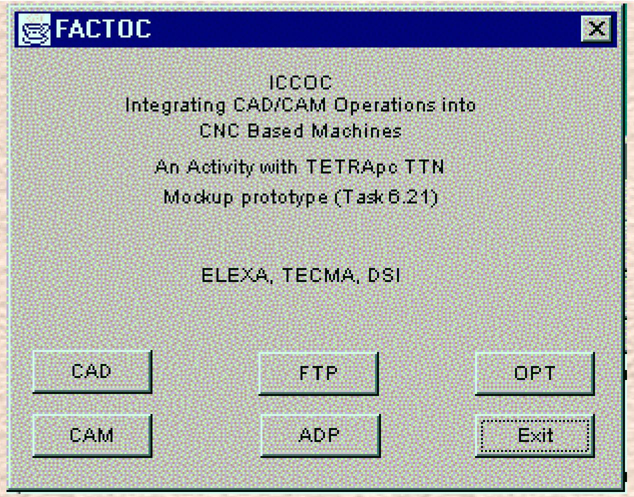


UNIX CAM in an NT CNC Console. Click to see a more detailed image (**98 Kb**)

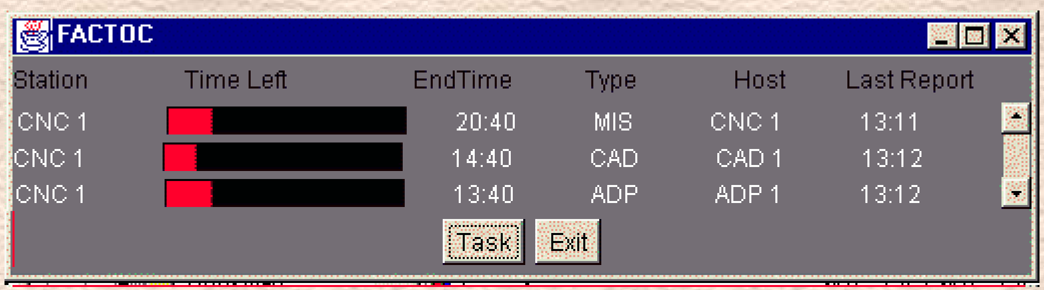
Consider a running CNC that has no problems, the operator is constrained to stay in front of the CNC without performing any productive activity.

By now with ICCOC your employer can modify some CAM parameters or adapt the NEXT piece to be done for its CNC.

The client main window of ICCOC demonstrator: FACTO. All operation, like, CAD, CAM, File Transfer, etc. are available on a single mouse click. Click here to see the snapshots, showing the various ICCOC facilities.



Yes the NEXT piece, because ICCOC optimizer says to the operator which is the next work to perform saving time to ask instructions from the department boss.



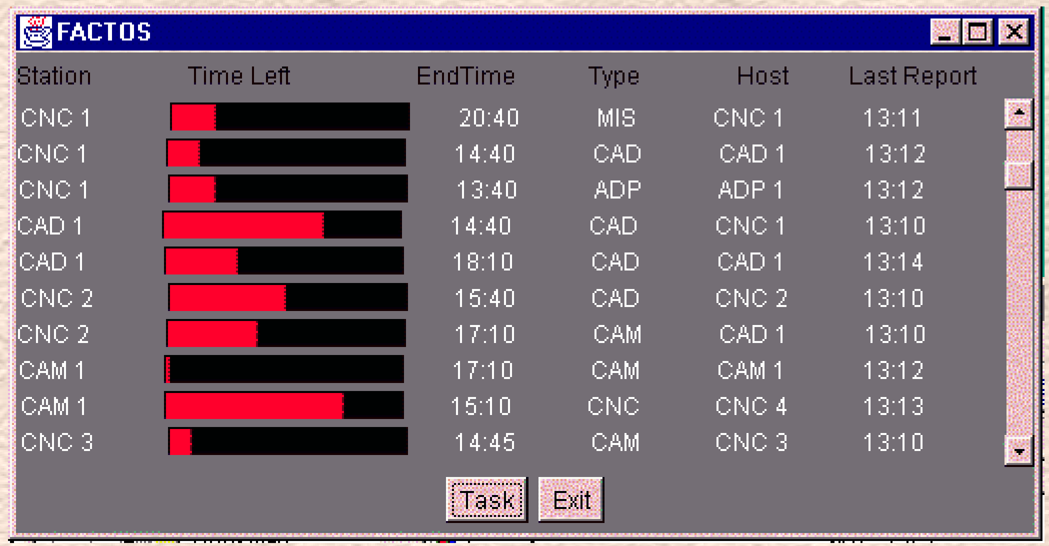
The FACTO Client Optimizer shows to the operator all the operation to be performed on the CNC that he controls.

20% improvement in productivity

20% improvement in productivity

Considering that you have a 60% reduction of dead time in Re-CAD, Re-CAM, going around and so on (activity that cover about 25% of your employers time) you can improve your productivity of 15%.

The remaining 5% of improvement is given to you by the facto optimizer that can help you to select free resources at the correct time, reschedule your works in any moment reducing further dead time and improving again and again productivity.



The FACTO Server shows to the manager all the work (and their status in real time) for all the CNCs and CAD/CAM/Adaption stations in the factory.

Requalify CNC Operators

Requalify CNC Operators

Using ICCOC your employers will acquire more knowledge about all the instruments used in your company. They will be able to solve some minor problems without the assistance of a CAD or a CAM operator that can continue to work on other projects reducing time to market for your company.

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

FACTORY INTEGRATION:
CAD/CAM ON MACHINE TOOLS

ELEXA & TECMA

ICCOC project has demonstrated the possibility of integration of CAD/CAM functionality on CNC-based machines by means of HPCN technology. The integration of CAD/CAM allows the reduction of costs related to non planned CAD/CAM activities of at least 35 %. Milling Machines, for making templates are typically used for producing unique and special templates. These usually need several CAD/CAM remakes on the basis of the machine adopted, on the machine configuration, and on the shape of the coarse piece from which the template is obtained. These facts and the lack of integration between CAD/CAM and MMs areas cause large problems of delay. The main result has been to pose the basis of implementing a new category of products for integrating CAD/CAM and MMs areas obtaining an optimal exploitation of resources. This has allowed the opening and the conquer of a new market, and as well as the consolidation of the present market. This activity was carried out under the TETRApc TTN. TETRApc can be contacted by email (nesi@dsi.unifi.it, nesi@ingfi1.ing.unifi.it) or by telephone (+39-055-4796523) or FAX (+39-055-4796363). The initial contact is Paolo Nesi.

Click here to see or download full version of success story (87 Kb)

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

Press Release

F.Butera, B.Fontanella, P.Nesi and M.Perfetti ***"Reengineering a Computerized Numerical Control Towards Object-Oriented"***, In Proc. of CSMR 98 pagg. 224-227, Florence Italy, March 8-11 1998

F.Butera, P.Nesi and M.Perfetti, ***"CNC di Qualità per Produzioni di Qualità"***, Meccanica & Macchine di Qualità, Rivista Italiana della Sicurezza e della Certificazione, Roma, n.1, pp.10-19, 1998.

Elexa and Tecma, ***"Factory Integration: CAD/CAM on Machine Tools"***, ICCOC Success Story (see or download in PDF format 87K)

Elexa, DSI and Tecma, ***"Public Final Report of ICCOC: Integrated CAD/CAM Operation into CNC-based machines"***, (see or download in PDF format 265K)

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

ICCOC Objectives

The objective of this project has been the identification of a suitable network to support the integration between the CAD/CAM area and the machine area so to allow a reliable and fast remote execution of CAD/CAM applications on MMs console concurrently to the machine control, the dynamic optimization of CAD, CAM and MMs resources, fast and reliable transferring of very large quantity of data.

ELEXA (the technical consumer of this project) point of view.

The improvement of the integration between the CAD/CAM area and the Machine Tools should encompass the hereinafter aspects:

- **remote execution of CAD, CAM directly on the CNCs of the Milling Machines**
- **transferring of files among the several workstations of the factory should be implemented by using FTP or other higher level more reliable mechanisms**
- **monitoring the activity of the factory**
- **advertising (remote or local) the production manager**
- **planning and re-planning the activity in order to optimize the process of production.**

To realize these services, a prototype has been implemented.

The benefits are: the reduction of costs for Re-CAD and Re-CAM operations, the reduction of time for Re-CAD and Re-CAM operations, optimization of production process, same user interface for programs and re-qualification of the operator of the CNC.

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

The presence of CNC for controlling MTs has also provided the support for implementing complex strategies and thus for building specific MTs such as Milling Machines, MMs, for templates. These are strongly complex and completely re-configurable machines mainly devoted to make unique pieces with high precision of finishing on the machine. MMs for templates have to change, as fast as possible, their working program for each piece. Moreover, the description of these templates in terms of working program is very heavy since they must be produced with a high precision and this lead to have very large working programs -- e.g., several tenths of megabytes. Precision, also means to have very specialized and costly MMs. The pieces are defined on CAD/CAM stations but their design must be frequently customized changing shape, and CAM parameters. This need leads to a heavy exploitation of CAD/CAM stations for small and MMs-related issues that are in many cases very far from the CAD/CAM user mind-set. For these reasons, some builders have decided to integrate on CNCs for MMs also operations partially performed on CAD/CAM stations; but their functionality are very far from those of a full CAD or CAM.

In the enterprises, which base their economy on producing templates, it is necessary to reduce as much as possible the time during which the machine does not work -- i.e., from the working of a template to the next one -- the so called *dead time* of MM. These enterprises usually adopt a workstation for the production of the template design on a CAD. The CAD design generation involves many man-hours and has as goal a mathematical description of the mechanical model. On the basis of the output produced by the CAD, the so called CAM module generates the working program (often under neutral form), for example neutral ISO (where some information are lacking and others need to be modified). This activity of modifying and fitting is implemented according to the MM technical information: (i) the size of tools, (ii) the machine structure (as number of axes, relationships among axes, moving modalities, etc.) and according to quality and final finishing up requirements of the part same. In particular, the commercial CAMs are capable to produce working programs in neutral form, on the basis of a CAD design and some technical information. These are independent from the kind of MM and from the shape of the rough part from which the template will be obtained. This makes the CAD/CAM outputs (Neutral ISO, NISO) totally independent on details of the MT and on the dimension of the coarse piece.

To resolve this gap, CNCs builders have the duty to fit the neutral program to the various controllers and to the various MMs through fitting up program (sometimes called post processor or adaptation process). For this purpose the CAM output is provided with a set of adaptation programs, one for each type of MM which is present in the plant. So the CAM adaptation activity must be repeated for each MM, it is often necessary to repeat it for each part since the working program can change also according to the size and shape of the coarse piece of metal from which will be obtained the template. A different material removal involves a different tool path. It is also worth saying that the operator, who works at the CAD/CAM station, often does not know on which MM it will be implemented the template he/she is designing. MMs are usually very specific and hence each of these is substantially different from the other (at least as regards the same workshop) with respect to geometrical characteristics, tools, working velocity, etc. Such sizes are fundamental for obtaining the working program in the definitive form. Therefore, the MM selected influences the operations for customizing the ISO working program, to modify it according to technical characteristics of the MM and for considering the dimension of the coarse piece. In order to save dead time, the activity of adaptation should be specifically required by the CNC a short time before executing the working program in final form.

If the CNC is based on a computer with enough power, a possible way to work consists in executing the CAM and adaptation processed by the operator on the CNC itself. In this case the operator describes the actions to be performed by the MM starting from the paper version of the design produced by the CAD with the support of suitable tools. This method is pertaining to programs that are referring themselves to plane geometry parts that compose the solid. For example, the CNC user might need to carry out a

working on a template in order to change a part of it. This kind of solution has been suggested in order to reduce the time needed for reporting the modifications directly on the CAD/CAM station by using CAD/CAM personnel. In fact, when a small modification is needed its execution on the CAD/CAM station is a very time consuming task for both CAD/CAM and CNC operators. This solution has been proposed by CNC builders as a technological evolution compared to the previous one (since it is possible only on machines having high performances CNCs). On the other hand, it involves greater costs for the machines, which have to provide the necessary power to control MM and to execute CAD/CAM activities in short time. This functionality could be considered as a further possibility to be used when the working program generation is not conform with the requirements and it is necessary to re-execute both CAM and adaptation phases.

On the contrary, to make the modifications on the mechanical pieces directly on the MT leads to provoke a gap between CAD/CAM descriptions, documentation and the obtained template. The control process and thus the feedback needed for increasing quality is broken. Moreover, this type of solution has been also used for the lack of a true integration and quick communication between the machines tool department and that where CAD, CAM and adaptation phases are carried out.

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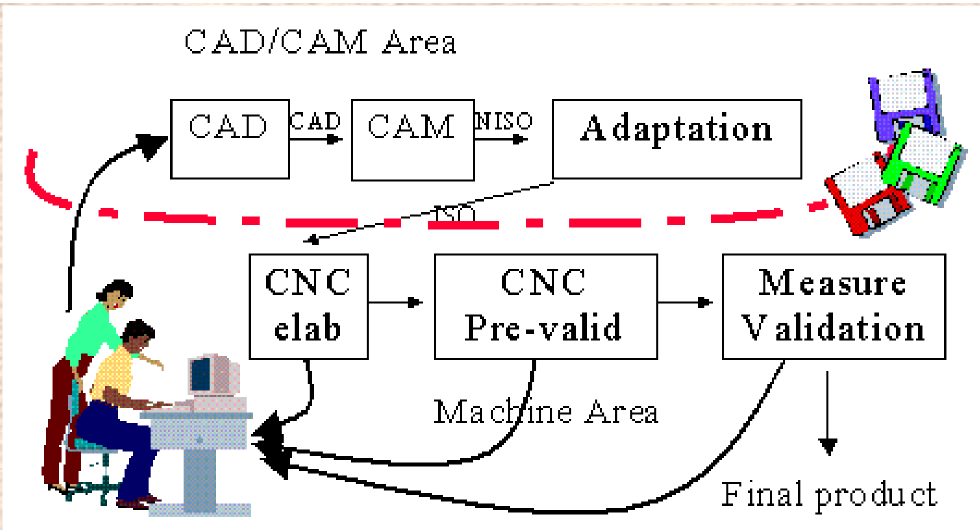
Integration between CNCs

Since long time, in the literature, various low-level communication support have been provided -- e.g., Ethernet, Token Ring, Token Bus, FDDI, ATM, BITBUS, CAN, BACnet, CEBUS, etc. Some of these are typically used for transferring data -- Ethernet, Token Ring, Token Bus, FDDI, ATM, etc... - while the other for control -- BITBUS, CAN, BACnet, CEBUS, IEEE-488, ISP, Lonworks, WorldFIP, ProfiBUS, InterBUS, etc. To this purpose, in literature various protocols for real time distributed systems management there exist.

Despite to the above experiences, the most important CNC builders make possible the interconnection of MTs with a machine playing the role of production supervisors through serial connections or "ad hoc" solutions. It should be noted that the adoption of local networks is not commonly diffuse for implementing DNC policy. Siemens proposes in its catalogue a network based on Ethernet IEEE 802.3 (CSMA/CD) 10 Mbits, which allows to connect several CNCs; it has furthermore defined a high level protocol (SINEC). Bosch allows the implementation of DNCs by connecting CNCs having interfaces with EDNC, LSV2 protocols, or the simplified RS232 and RS-422; furthermore PROFIBUS - Field Bus processor standardized according to DIN 19245 standard- is used for data exchange among PLC, also of various producers. NUM (France), FIDIA (Italy), SELCA (Italy), FANUC (Japan), GRUNDIG (Germany), DAIMLER-BENZ (Germany), and ELEXA itself (the coordinator of this project) use Ethernet 2 Mbytes for communicating among CNC with similar results as better explained in the following. As a conclusion, only low bit rates or unreliable supports have been used. This way to work corresponds to the state of the art of the interconnections among machine tools in industrial environments. These communication mechanisms are frequently used for both controls and data, also for establishing a connection between machine tools and CAD/CAM area.

Integration between CAD/CAM and MT areas.

In a typical enterprise, there are usually M MTs, M/2 workstations for CAD and M/2 machines for the execution of CAM and Adaptation applications. The MTs are furthermore supported by robots for charging and discharging pieces and tools from automated storage platforms. These automatic systems of support are usually controlled by the CNC of the MT served. In the working area also Measuring Machines, MEMA, on which templates and final pieces are measured to evaluate the conformity with the starting requirements and hence to validate the template production are present. Template measures are usually checked on the basis of a paper version of the piece. The state of the art about the communications between the CAD/CAM/adaptation environment and the area in which are located MTs/MMs for measuring and producing pieces is carried out off-line through magnetic supports. Only seldom there exist enterprises in which a network support is used to transfer working programs through FTP. Some of the CNC builders mentioned in the previous section provide a network only for distributing control by using low band networks and not for transferring to CNCs large quantities of data. This is mainly due to the fact, that a large part of MTs are used for production where the same working program is executed several times before to pass to a new one. This is confirmed by the fact that they are using Ethernet support.



In the industries producing templates, there exists a strong interest in the integration of CAD/CAM with the factory part in which MMs, measurement systems, robots, etc., are present. The integration must be supported by a fast and reliable communication between these two areas for making available

i. **in real time working programs directly on CNCs without transferring them by using magnetic supports or by using slow and unreliable networks,**
ii. **the possibility of the remote execution of CAD/CAM/adaptation directly on the CNC console.**

The execution of CAD/CAM applications on MM consoles must be supported by mechanisms for dynamic optimization of CAD, CAM and MMs resources.

The same network could be used for delivering commands that are typical of CIM policy (monitoring and planning activities carried out by machines). By using a such network support and general services the CIM policy can be expanded to plan also the CAD/CAM/adaptation activities.

The above mentioned requirements seem to be contradictory since the transferring of working programs in short time (from the CAM and adaptation stations to CNC) needs a high throughput, while the sending of commands in real time (synchronization commands, alarms, etc.) means high reliability and predictability.

It is in our opinion that these problems can be solved by adopting a fast and reliable supports based on a priority based protocol such as 100VG, ATM, etc. Even Fast Ethernet (100 BT) if it is carefully used. These are typically problems solvable with HPCN technology. Other networks or control networks are less predictable or too slow (CAN, Token Ring, Lonworks, WorldFIP, PROFIBUS, etc.).

Very few CNCs builders are experiencing communication networks: see the following European conferences: Asi95 (intelligent control and integrated manufacturing systems), CEBIT95 (Information and Communications Technologies Fair) ESPRIT-CIM94

(European Conference on Information Technology, Iim95 (Integration in Manufacturing and the latest SMAU, BIMU and EMO in Milan.

This ICCOC stand alone assessment has been a preparatory study only slightly related with others EC projects such as: PLENT 20723, NetCIM 9901, AITIME 9902. The above mentioned relationship is a mere concept since none of these projects study the solutions for the above described CAD/CAM and MMs areas integration problems, even if these problems are not yet solved as demonstrated by the lack of commercial product provided by CNC builders. In addition, some of the mentioned projects give for granted that these problems exist and have as aim only the definition of the information exchanged among machines. There is a relationship also with the ESPRIT projects: OSACA 6379 (Open System Architecture for Controls with Automation systems) and MOSAIC 5292 (Modular open systems architecture for industrial motion control). The main aim of these latter projects was the definition of flexible distributed architectures at system control level, without solving specific technical interconnection problems in very noisy areas such as workshops, without considering the integration problems between CAD/CAM/adaptive machines and the CNC-based machines.

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The selection of the most suitable network support was made considering high throughput in critical conditions, physical layer, technology, drivers and development software availability.

Ethernet (IEEE 802.3), Token Ring (IEEE 802.5), Fast Ethernet 100Base-T (IEEE 802.3U), ATM, FDDI, 100VG-AnyLAN (IEEE 802.12) have been evaluated.

Among the mentioned network supports the 100VG and the 100BT have been the most interesting for the performance/cost ratio. ATM and FDDI are too expensive, this is due to the needs of fiber cables and special HUBs. 100 VG AnyLAN is more reliable than 100 BT. In certain conditions even 100BT can be profitably used (bandwidth required £ 40 Mpbs and the communication are mainly 1:1). In some special conditions, when high throughput must be guaranteed, specific switches HUB can be used. Most of the tests that have been performed on the network can be replicated on both the supports with minor changes. The operations of remoting, ftping, etc. can be performed on the basis of TCP/IP protocol that is totally independent from the network support used. The previously mentioned facts place the basis for using both network supports. 100 VG and 100 BT uses the same category 5 cables and they have quite the same response to the noise when the Switch HUB is used for 100 BT. HP has decided to remove from the market the 100 VG, it is probable that others 100 VG vendors will increase its price on the market. This will make more interesting the solution based on 100 BT in the next months.

For the tests, a network based on 100VG connected to a 10BT has been used.

The network topology and hardware (wirings type, board models, HUBs, etc.) adopted for the ICCOC project consists in a 100VG HUB connected to several CNC/MM, CNC/MEMA, and CAD/CAM stations having 100VG network adapter and a bridge toward 10Base-T thin Ethernet HUB connected to Unix station (without the 100VG Adapter).

For the Remote execution of CAD/CAM/Applications the best solution seems to be the Remote Window Server Terminal Base. UNIX possesses functions that re-direct the flows of the applications towards a new terminal on the network. For Windows NT, independent software manufacturers have commercialized terminal substitutive (X-Win, X-Win32, Window Based Terminal Server, etc.).

For the file transfer the standard FTP is strongly diffuse and easy to understand, so this is the protocol chosen.

For the Production Process Optimization (monitoring the factory activity and optimizing resources according to simple schedule mechanisms and considering the status of a database containing specific information) the best solution seems to be the Intranet Technology Specific Application. Several intranet techniques for building applications have been proposed.

For the Remote execution of CNC, the full remote control (software applications that allow to remotely acquire the total control of the session excluding the original customer: PC Anywhere, Laplink) or Intranet Technology Specific Application seems to be the better solutions.

Several tests have been performed in order to verify the response in bandwidth and the CPU Utilization during the various tests, for the 100VG network connected to a 10Base-T network for interfacing with a Unix Workstation that provides the CAD and CAM programs. The using of a 10Base-T network for the remoting of the CAD does not limit the results, because, like the tests will

demonstrate, the load generated by the remoting is so low that a standard ethernet is sufficient.

In the tests, the typical conditions of the manufactures analyzed have been simulated and the typical operations have been performed. The requirements have been evaluated in an environment rich of electromagnetic noise at TECMA, that plays the role of a typical hand-user in the ICCOC project, in order to create the worst case conditions. In order to create base workload, a couple of programs named NETSERVE (server program) and NETPERF (client program), running under Windows NT, have been used. These programs generate traffic on the HUB (http://www.netperf.org/netperf/NetperfPage.html). The running of the above-cited programs on one, two and three couples of CNC stations generates the traffic. The stations that are not used to perform such operation are devoted to test and measure network load. The measure of the load on the HUB is performed by a program provided by HP that requires that the measuring WS is connected to the debug port of the HUB with an RS232 cable.

Referring to the prototype (mock-up), it has been capable of testing the most important features identified before, it must be integrable in the final environment consisting of a set of workstation with both Windows NT and Unix OS. For the development of the prototype, the object-oriented technology has been used. In particular the object-oriented methodology for system development has been used. At level of Management, the methodology of DSI and ELEXA has been applied.

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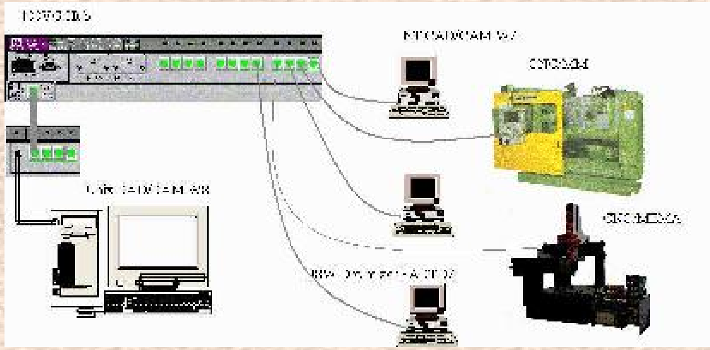
The Network

The network topology that has been adopted for the ICCOC project consists of a 100VG HUB connected to several CNC/MM, CNC/MEMA, and CAD/CAM stations having a 100VG network adapter and a bridge toward 10Base-T thin ethernet Hub connected to Unix station (without the 100VG Adapter). The topology is presented in the following figure.



Click here or on the image to see a bigger image more detailed (44K)

The hardware components used for the 100VG network used are summarized in the following table.

Hub	**HP J2415A - AdvanceStack 100VG Hub-14**
Bridge	**HP J2414B HP 100VG/ET SNMP/Bridge Module**
Transceiver	**HP J2608 ThinLan**
Network Adapter	**HP J2585B DeskDirect 10/100VG PCI LAN Adapter**
Cables	**UTP Cat. 5**
Connectors	**RJ-45**

The other components are a classical 10Base-T HUB with both RJ-45 and BNC connectors connected to the Bridge Transceiver of the 100VG Hub, the internal network adapter of the Unix WS connected to the 10Base-T Hub with a Thin coaxial with the standard BNC connector.

The Mock-Up Prototype

A mock-up prototype (also called FACTO) to validate the assumption made was implemented. It consists in a distributed application designed and implemented by using object oriented technology, in particular the object oriented methodology for system development will be used. At level of Management, the methodology of DSI and ELEXA will be applied.

The main tasks the prototype accomplish are:

1. **Activation of the remote execution of CAD/CAM/Adaptation workstations on CNC and MEMA machines.**
2. **Activation of file transfer from the machine containing the file(s) and that which has to used it.**
3. **The possibility of Monitoring and Measuring in real-time the activity of the factory and that of its components.**
4. **The possibility of Planning and Re-Planning in real-time of the activities of CAD, CAM, Adaptation workstations, CNC and MEMA machines.**

The two last points are based on the assumption of building a FACTO Server to organize schedule and make the all services that are available on the network to the several Clients. For these reasons, FACTO can be considered a sort of mechanism for virtualizing the services that are available on the network. The FACTO Server could be located in a machine dedicated to its execution. The Clients are located on CAD/CAM/Adaptation Workstations, on CNC, and on MEMAs. The ICCOC prototype can be considered the early demonstrator of FACTO architecture comprised of a Server and a set of possible Clients.
FACTO provide an User Interface for:

- **FTP sessions. It is the basic network operation in CNC environment. Prototype grants:**
- **Commands simplification: Ftp transfer requires a rigid command succession that can be totally automated to allow working time saving.**
- **Security: prototype, by automatic localization and transfer, grants a selective access to files and directories to assure safety of other CNC operations.**

  Start CAD, CAM and measurement software remote operation: Prototype would open the remote session in the available network host by a simple button click.

Facto Client and an active CAD session on a running CNC. (Click here on on the image to see a more detailed one)

Facto Client and an active CAD session on a running CNC with a performance monitor in execution. (Click here on on the image to see a more detailed one)

The main results obtained by the prototype are that remoting UNIX applications on Windows NT is quite simple by using one of the several products for remoting X Terminal on Windows NT. Remoting Windows NT Applications on Windows NT can be done in several manners -- e.g., by using PCAnywhere, LapLink. By using the Window Based Terminal Server (the so called Hydra) which is currently under beta-test and will be included into the Windows NT 5.0 for Servers. Moreover, remoting Windows NT Applications on UNIX is possible by using special applicative programs, and also remoting UNIX applications on UNIX is not a problem by using X terminal.

Referring to the file transfer, this is really simple since all UNIX and Windows NT machines can used FTP based on TCP/IP.

FACTO is a prototype for future operations like:

- **Automatic optimization of resource with a real time scheduling algorithm.**
- **Monitoring in real time of all task time and of all working deadlines.**

In order to realize FACTO Java 1.1.4 of SUN Microsystem has been adopted. Java has been selected among the most diffused language for the features it can collect:

- **Java is easy to learn and easy to use;**
- **Java is Object Oriented;**
- **Several Just in Time Compiler are available to compile the code in native microprocessor code machine;**
- **Java is portable over a large number of different platforms, and in particular under most diffuses Unix and Windows NT: WS using different operating systems can use the same server program without modification.**
- **Java has several native classes for supporting distributed systems Remote Method Invocation (RMI) and interface Object Request Broker (ORB) for the accessing to Object Oriented Databases. These features have permitted to create on the server object which methods are executed directly by the clients.**
- **Java can execute code in native language (like C++) thanks to JNI. In Windows NT JNI allows the interface between Java and C++ DLL that can run native 32 bit applications.**

In the Test of Prototype, the prototype and its functionality has been tested. It includes the verification of performance of the network when it is used for remote execution of applications and for transferring large amount of data (such as working programs).

It is very important to measure both bandwidth used on the 100VG HUB and CPU Utilization for CNC Workstations during the execution of the various tests in order to verify the feasibility of operations.

In the test of the Remote execution of the UNIX CAD and visualizing its GUI on ELEXA-CNC, under different three base workload conditions (0, 40 Mbps and 68.4 Mbps), the Unix CAD is remoted on a CNC station, while another CNC station measures the load on the 100VG network. During the remoting of the application the increase in CPU Utilization for CNC is monitored in order to verify the load on the station during the normal future operation.

In the test of the Remote execution of the UNIX CAM with rendering and visualizing its GUI on ELEXA-CNC, under the previously cited different base workload conditions, the Unix CAM is remoted on a CNC station, while another CNC station measures the load on the 100VG network. During the remoting of the application the increment in CPU Utilization for the CNC is monitored in order to verify the load on the station during the normal future operations.

In the Tests about the Possibility of Remotely Control CNC from another CNC (sometimes it's necessary that a single operator controls more than one CNC; in order to allow this mechanism it's necessary to remote the console of a CNC on other CNC), the bandwidth necessary to perform such an operation, and the cost, in term of CPU utilization both for client and server CNC, are measured.

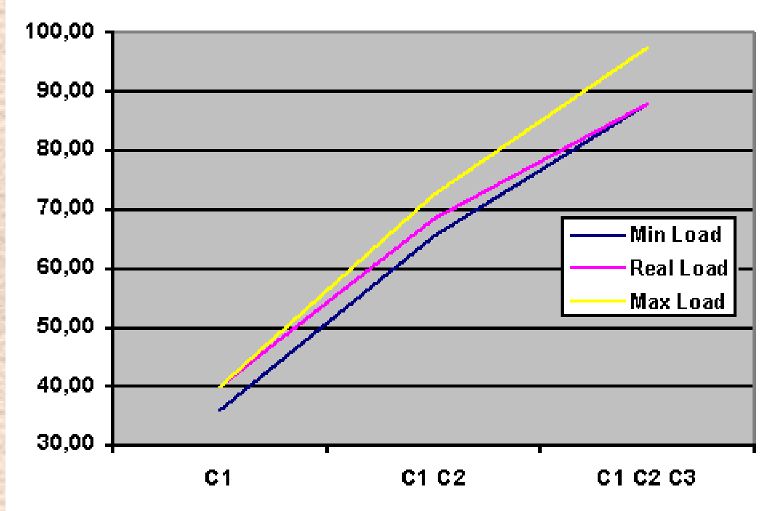
In the test about the Transferring Files, we performed a file transfer between two NT workstations and in particular from CNC/MM to CNC/MEMA station. In a second test the files are transferred between a couple of stations M1, M2. At the same time M1 requests files from M2 and M2 requests file from M1. The test are made via Unidirectional FTP and via Bi-directional FTP.

In the tests about the Possibility of Measuring, Planning and Re-Planning, we adopted different workloads on the network simulated by:

- **Activation of the remote execution of the CAD;**
- **Activation of the remote execution of the CAM;**
- **Activation of the remote execution of an FTP;**
- **Testing of the client-server architecture of the prototype when several clients are open and operate on the same data;**
- **Testing of the client-server architecture of the prototype when several clients are open and operate on different data.**

By the report of the result we found that:

- **The load of the Prototype on the network can be neglected with respect to the other loads**
- **Remoting is feasible and cheap**
- **Is also well considered by End Users**
- **Network support chosen is adequate**
- **Real economical benefits have been detected by end users**



The figure reports the load of the network. In order to measure the effective performance, three couple of machines have been tested separately so to evaluate the maximum load on the HUB. The HUB has been guaranteed to have at least 90%.

Detailed results of test can be found following the links reported below:

- Test about Remote Execution
- Test about the Possibility of Remotely Control CNC from another CNC
- Test about the Transferring Files
- Test about the Possibility of Measuring, Planning and Re-Planning

Comments about Remote Execution Tests

Examining the results of all the previously presented tests and considering that the Execution of Windows NT provoke a maximum load of 2% on the Cpu, it is evident that a single CNC machine is able to perform all the operations tested at the same time. The percentage of Cpu that it is necessary to run CNC program is 20%, to remote a CAD is 20% (for CAM is 30%) and to remotely control another CNC station is 15%. When all the operations (NT+CAM+CNC Client+CNC Server) are performed at the same time, the total load on the Cpu is (2% + 20% + 30% + 15%) less than 70% and, therefore all the Cpu resources are not used. The load on the network is very low because each station that performs all the previously cited operation, generate a load less than 1 Mbps.

Comments about FTP sessions

This test demonstrates that about 6 bi-directional FTP session can be activated at the same time without collapsing the network.

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The project has been completed and the work performed has demonstrated the faithfully and the strong interest of such a product.
This opinion is shared by TECMA and from other contacted end users.

The solutions adopted in the mock-up prototype, implemented for the ICCOC project, can be profitable adopted as tested on the field. We found that:

- **Remoting is feasible and cheap**
- **Remoting Is well considered by End Users**
- **Network support chosen is adequate**
- **Real economical benefits have been detected by end users**

The benefits evaluated are:

- **Reduction of dead time for Re-CAD and Re-CAM: 60%**
- **Optimization of production process: saving 20%**
- **Re-qualification of CNC operators**

Thus a New Product and a New Market will be set.

The key elements for building new products and for going towards an actual integration of the factory are:

- **Remote execution of CAD, CAM, ADP, on CNC/MM and CNC/MEMA**
- **Monitoring the activity of the factory**
- **Planning and re-planning the activity in order to optimize the process of production.**

So the aspect of Islands integration (MTs/MEMAs/Robots) and CAD/CAM/CNC integration must be integrated.

The ICCOC project has been focussed on CAD/CAM/CNC Integration.

The whole view is going to be obtained by merging the results of ICCOC with those obtained by ELEXA on Islands.

The Costs for the real implementation of the mock-up prototype have been estimated about 900 d/m (concretely predicted on the basis of ICCOC feasibility study 15 classes x 3 x 20 days)

The above opinions are shared by TECMA and from other contacted end users: OMCS, B-Ticino, BVA, Cevolin, CB-Ferrari CALP, SL, IMES MPT, Lucchese Stampi Zago, SMP
Several other demonstrations are planned in order to verify if the requirements collected by visiting the end users have been correctly interpreted

On The Basis of the Early Prototype some Concrete Agreements for implementing ISLANDs including ICCOC capabilities: FABOHA (Germany) ELSATECH (Italy) ZAGO (Italy)

This work will place also the basis for studying suitable policies for optimizing the exploitation of resources of the factory (CAD, CAM, CNCs, etc.: a distributed application for optimizing the exploitation of the resources in the factory: Measuring, Planning and Re-Planning in real-time of the activities of CAD, CAM, Adaptation workstations, CNC and MEMA machines..). The implementation of the algorithms of resources optimization and managing could be the subject of a bigger proposal and project in the same applicative domain.

Distributed application for optimizing the exploitation of the resources in the factory: Measuring, Planning and Re-Planning in real-time of the activities of
CAD, CAM, Adaptation workstations, CNC and MEMA machines.

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The consortium includes 3 Partners:

HPCN technology consumer ELEXA

DSI

University of Florence

Technology provider

End user TECMA

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ELEXA S.r.l.
(prime contractor, HPCN technology consumer)

Via delle Panche, 38 A, I-50141, Firenze, Italy
Contact Person: Marco Perfetti
Phone: +39-55-43.51.19
Fax: +39-55-43.76.334
E-mail: elexa@tin.it

DSI (Department of System and Informatics)
(HPCN Technology provider)

University of Florence, Via S.Marta, 3 A , I-50139 Firenze - ITALY
Contact person: Paolo Nesi
Phone +39 55 47.96.523
Fax: +39 55 47.96.363
E-mail: nesi@dsi.unifi.it
WWW: http://www.dsi.unifi.it/~nesi

TECMA S.r.l.
(End user)

Viale XX Settembre, 78
50019 Sesto Fiorentino, Firenze, ITALY
Contact person: Massimo Giorgetti
Phone: +39-55-44.42.41
Fax: +39-55-44.42.41

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The Reference TTN

For the ICCOC activity, the partners have chosen to select TTN-TETRApc as their ``reference TTN'' that proposed by CPR (Consortium Pisa Ricerche, Pisa, Italy), CESVIT and CSM. In particular, CESVIT High-Tech Agency (a no-profit agency) has been selected by ICCOC partners as the reference TTN-TETRApc site.

It should be noted that CESVIT for TTN-TETRApc activity collaborates with the Department of Systems and Informatics (DSI partner) which provides support about the technological and scientific aspects of TTN HPCN. This collaboration is very suitable since the complementary roles of CESVIT and DSI within TTN HPCN have been well-identified. CESVIT has a very high visibility and sensitiveness with respect to the market, for distribution, advertising, evaluation, etc. activities (very useful for the management of the TTN-TETRApc), while DSI provides know-how in HPCN technologies (see the enclosed bibliography and biographies, Annex 4). According to the cooperation agreement between CESVIT and DSI for the TTN-TETRApc, the scientific responsible of the CESVIT part of TTN-TETRApc is Dr. Ing. P. Nesi of DSI. Please note that he is also the coordinator of the present activity.

TTN HPCN TETRApc

ARTIC

Consorzio Pisa Ricerche

CESVIT

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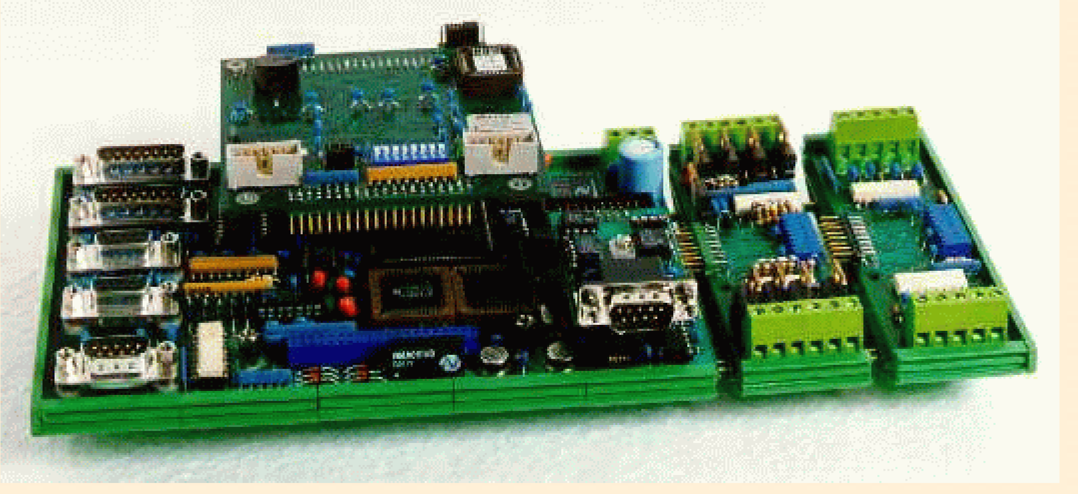
MUPAAC project consists in improving capabilities of an already present architecture for automatic control for industrial machines. It will make possible to reach performance better or comparable to the best which can be found in the market of automatic controllers at lower cost.
The targeted end users are builders of automatic machine tool (for cutting, soldering, moving, electron erosion, etc.) which can be used in pipelines of production. Main objectives and results of MUPAAC are:

- the adoption of HPCN technology for making performance of microprocessor based controllers of SED comparable or better with respect to the best which are available on the market, but at a lower cost/price for the machine builders. An increment of functionality is also planned;
- introducing HPCN technology for obtaining, on the basis of already available computerized control of SED a flexible and reconfigurable parallel/distributed system for control in order to reduce the costs/prices for the machine builders of about 20 %. The system has been considered strongly needed for integrating automatic machines into pipelines of production;
- the deployment of HPCN technology for improving performance and decreasing of cost of products and thus for covering a wider market;
- the dissemination of results at National and European levels.



Industrial Benefit

The proposed MUPAAC architectures will be very interesting for the machine builders, since it guarantees the return of the investment for developing the present proposal.

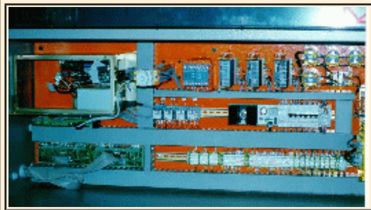
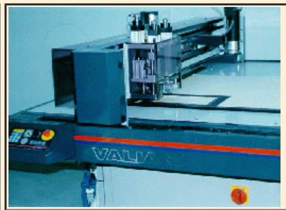
Machine builders are strongly interested to have:

1. ***a reduction of cost/price of about the 20 % for the CNC;***
2. ***a high flexibility since the same architecture could be used for covering different types of machines, different in performance and complexity;***
3. ***a controller which can be integrated in a pipeline of production (FMC line) by means of a fast connection;***
4. ***a scalable architecture on which several robots and services can be added even later without restarting from a new CNC but only adding the components needed;***
5. ***a set of new functionalities due to the integrability of the machines with the others of the same area.***

The above needs can be satisfied by using HPCN technology for building a flexible multiprocessor architecture for automatic control. Thus, this architecture:

- **must be flexible. In the sense that on the basis of the performance required different configurations will be possible with corresponding scalable cost/price for the end-user/machine builders;**
- **must be less expensive with respect to the typical price of the market, previously reported**
- **must be connectable with other automatic controls in order to build automated areas.**

MUPAAC at Work

	Click to see a more detailed image.		Click to see a more detailed image.

Success Story

HPCN Reduces Costs of Production Pipelines

SED & VALIANI

A pipeline of production presents several elaboration phases in which the movement of interpolated axes is needed. These activities have to be synchronized with the several other activities and switches along the pipeline.
Numerical controls for such a system have to be flexible and strongly expandable since the pipelines are frequently reconfigured and different pipeline may have strongly different technical requirements.
MUPAAC project is a solution for implementing flexible architecture for the automatic control of industrial machines. With MUPAAC is possible to reach performance better or comparable to the best which can be found in the market of automatic controllers but at a lower cost/price: a reducing of 23% for the costs of controllers for the machine builders. With MUPAAC SED increased its market by improving performance of controllers. This has been obtained by passing from a simple dual processor architecture to a flexible multiprocessor architecture with the introduction of HPCN technology.

Click here to see or download the compressed full Word 97 version of success story (2Mb)

General Background

With MUPAAC activity, the partners intend to improve the capabilities of the already produced architecture (INDEX-DSP of SED employed by VALIANI on their machines) for automatic control of industrial machines. This will make possible to reach performance better or comparable to the best that can be found in the market of automatic controllers at a lower cost.

Presently, most of the automatic machine tool (for milling, cutting, measuring, moving, soldering, electron erosion, etc.) which are used in pipelines of production are controlled by microprocessor based systems. These are usually called CNC (Computerized Numerical Control).

The automated systems of production can be classified in three main categories. The first is usually defined as FMM (Flexible Manufacturing Module) {Montanelli96}. These are constituted by a single machine tool, for example a working center to which auxiliary robots for charging and discharging parts and tools, are added. Moreover, sometimes also measuring machines complete the area. The FMM control consists in a single microprocessor based system that coordinates the machines and the auxiliary tools and services (e.g., 3 axes for the machine and 2-3 axes for each robot of service). The second category is the FMC (Flexible Manufacturing Cell), it constitutes the core of several FMM modules. These are connected by automatic mechanisms for transferring pieces among FMMs etc. The production process management of the cell is managed by a central control unit. All FMMs of the FMC have their own controllers which talks to the central processor by means of a local communication network. In this case the number of axes can be, as a limit, even 64; thus, 3-4 for each CNC.

A further factory's automation model is the FMS - Flexible Manufacturing System. It represents the consecutive level of the production cell in the development of the production and diversification capability of an industrial plant. It is made by more production cells which are connected with a central data processor which manages besides the various production cells also the production flow control, for example orders and stock house supplies. A quick analysis made by the distributors of the most important numerical control producers shows encouraging results for starting a research in this field. Among the most important CNC's producers only SIEMENS owns a network based on international standards IEE 802.3 (CSMA/CD), which allows to link each other more axes controllers. In this case, the communication among controllers and process management computers occurs through some bridges that connect each other the controllers network with that (token ring type) of the process management data processors. Many others firms such as OMRON, ABB, Blue Chip own communication networks which connect each others only PLC modules. The American enterprise Intelligent Instrumentation uses an Ethernet network to connect its own field bus modules such as Profibus, Bitbus or CANbus. These connection types are Master-slave, that is to say that the Master manages the communication, typical centralized non distributed controller. The electronic systems produced by SED are mainly used for the machines management which belong to the first type, FMM, and in lower quantity also on FMC systems. Recently there is an international strong request for the realization of FMC and FMS systems.

In general, a CNC system receives the instructions describing the elaboration to be performed in terms of an ISO program. These are generated by CAD/CAM stations on the basis of tools used on the machine and considering many other details. The ISO program is composed of elementary instructions (usually called blocks), and each block may include instructions to coordinate the macropoints for interpolation (plus eventually some technical information). The CNC system, by using the interpolator, calculates the micropoints that are useful to generate the profile required between the given macropoints. The operation of a CNC can be summarized as follows:

- **Interpretation of ISO programs coming from (i) the console, (ii) diskettes, (iii) a network connection, for translating each instruction in low-level commands. Specific versions of ISO programs can be used for both describing the operation to be made by the machine and by its I/O ports by using logic equations;**

- **Execution of low-level commands for axes of the machines and for the other auxiliary services by means of several digital and analog input/output ports; these are usually called in short ``I/O ports'';**
- **CNC controls the execution of each command and action by using the information coming from the machine by means of sensors, etc.**

The CNC is capable of detecting errors/faults that may occur on the machine. These are corrected by special set of instructions and/or are reported towards the other microprocessor based systems which are monitoring all the automated area according to FMC policy.

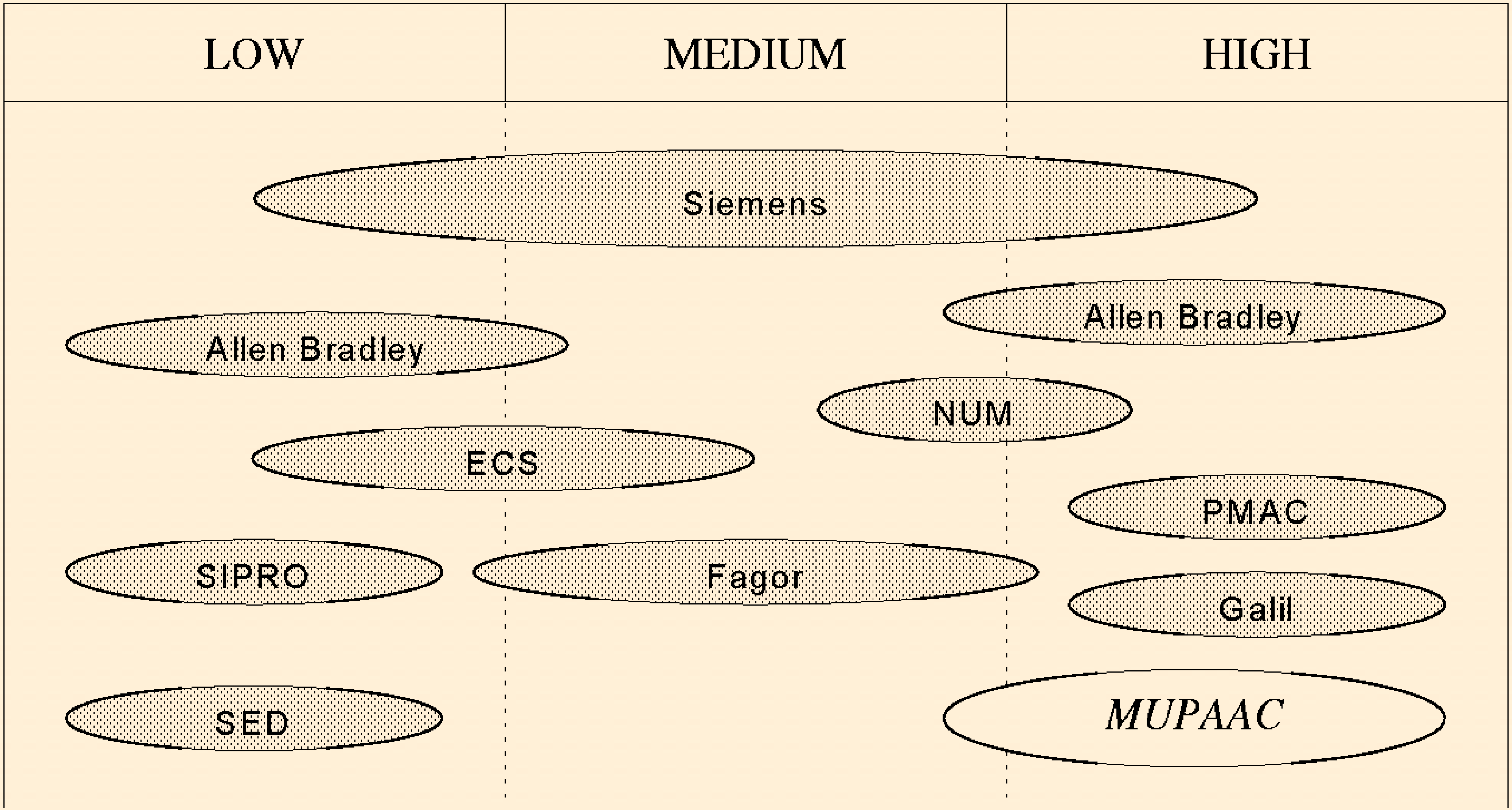
In the specific field of builders for cutting machines for producing passpartout (as VALIANI, end user partner of this project) (e.g., ZUND, Swiss, Gunnar, Swiss), the machines can be integrated in FMC areas only by means of slow communication supports (e.g., RS232). These machines are also critically served by robots for loading pieces and/or tools.

Market Situation

In Europe there exists more than 7500 automatic machine builders. All these builders produce about 500000 complex machines per year (more than 8 axes), these are installed in all world (information coming from UCIMU and CECIMO, Italian and European association of machine builders, respectively).

In the market, there exists several builders of CNC; some of them are strongly oriented to support FMM architectures. Those which are capable of controlling FMC areas can be classified in three main categories on the basis of the refresh time (period) for evaluating/generating the actions on axes, Ref.Ax. For lower values of Ref.Ax. we have higher performance and costs, since a short refresh time leads to reduce errors (in cutting, soldering, etc., i.e., in following the planned profile) and executing elaborations in shorter time. In Fig.1 a schema presenting the classification of control builders is shown. According to our market analysis, which has been performed by interviewing machine builders, studying related documents, making direct questions at fairs, and by performing direct experiments, the following features have been identified:

- **HIGH performance controllers/market (Ref.Ax < 1msec): PMAC (USA), GALIL (Israel), Allen Bradley (USA), Siemens (Germany), NUM (France), etc. In this case, the price is about 725 Ecus per axis.**
- **MEDIUM performance controllers/market (with 1 msec < Ref.Ax <7 msec): Fagor (Spain), Siemens (Germany), etc. In this case, the price is about 420 Ecus per axis.**
- **LOW performance controllers/market (with Ref.Ax 7 msec). SIPRO (Italy), SED with INDEX-DSP architecture (Italy), ECS (Italy), Siemens (Germany), etc. In this case, the price is about 300 Ecus per axis or less**



Please note that some firms present several types of solutions which are capable of covering different sectors or the market -- e.g., Siemens, ECS, etc. Presently the controllers which are employed on cutting, soldering, moving, machine tools belong typically to MEDIUM and LOW categories. The adoption of high performance will improve the precision of elaboration allowing the adoption of more complex tools such as lasers, elaborations directly at the final resolution on milling machines, etc.

All the above mentioned architectures are quite modular, in the sense that most of them present a simple module for managing the single CNC/FMM, with eventually all its services. On the other hand, for implementing FMC architectures, some of them use communication networks, while other adopt mechanisms for synchronizing single FMM by using connections among digital I/O ports. For all the above mentioned solutions the price is quite proportional with the number of axes as highlighted in the above list of items.

Presently the complexity of FMC is growing since they need a higher number of robots and services. Some of these services need of many axes for their control. This local complexity of control cannot be managed by using decentralized numerical controllers since the remote connection by means of serial or specific channels is not fast enough {Raji94}, see http://www.synergic.com. For these reasons, some builders are improving the capabilities of their CNCs by increasing the power of the microprocessor. This augments the final price of the CNCs.

More recently, few builders of numerical controls in USA are beginning to build strictly coupled multiprocessor-based systems (parallel architectures) for implementing flexible CNCs and FMCs. This flexibility also reduces the cost/price of complex numerical controls and increase the modularity of the system.

For these reasons SED intends to transform its INDEX-DSP architecture in a multiprocessor architecture by using HPCN technology. These operations will allow to the new architecture of SED to cover a wider market and to reduce the cost/price of the product, even with respect other products, comparable performance, which are present in the market {Raji94}, see http://www.synergic.com.

INDEX-DSP of SED is a dual processor architecture in which a processor is devoted to interpreting ISO programs and generating macropoints while the other is a DSP (Digital Signal Processor) devoted to generating micropoints and controlling axes. The new architecture of SED, called MUPAAC, will be a multi DSP architecture in which a set of DSP boards will be connected to the main board by using a high performance bus.

Technical State of the Art

In the previous paragraphs, the technical state of the art of this sector has been reported.

Please note that, in the field of automatic controllers, there exists several European projects:

- **OSACA and OSACA II (Open System Architecture for Controls within Automation Systems),**
- **MOSAIC (Modular Open System Architecture for Industrial Motion Control) n.5292,**
- **ICCOC (Integrating CAD/CAM Operations into CNC-Based Machines),**
- **PLENT (Planning Small Medium Enterprise Networks) n.20723,**
- **NetCIM (Cooperative Network for CIME Technologies in Europe) n.9901,**
- **AITIME (Advanced Information Technology in Manufacturing Engineering) n.9902.**

For our knowledge only OSACA and MOSAIC have addressed the problem of parallel architectures for control, unfortunately by defining high cost and too complex architectures to be profitably used for low cost systems.

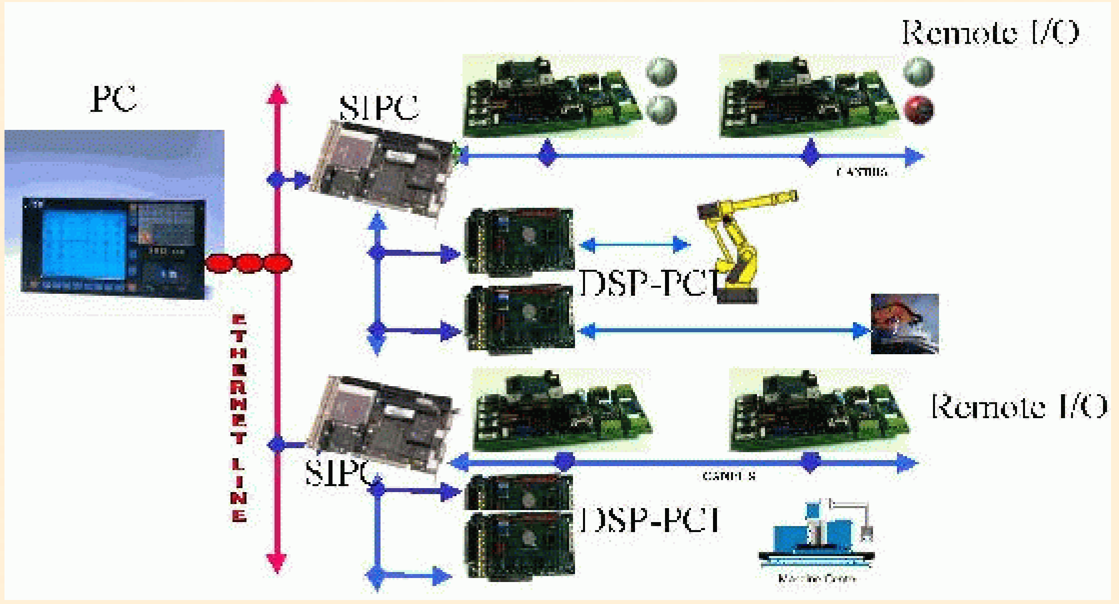
MUPAAC project will take into account the main results produced by these projects. Please note that MUPAAC is a flexible, reconfigurable, multiprocessor architecture based on PCI and DSP. This is a quite new idea.

The relationships with the rest of European projects (ICCOC, PLENT, NetCIM, AITIME, etc.) is a mere concept since all these projects are mainly focussed on the integration of controlled areas by means of networks according to a CIM policy.

MUPAAC General Architecture

A prototype of MUPAAC architecture for automatic control will be implemented by using HPCN technologies: parallel architecture, distributed system, communications, control networks, multi-microprocessor architecture; thus the name MUPAAC: Multi Processor Architecture for Automatic Control. The implementation of the MUPAAC prototype involves both hardware and software aspects (see Figs.2 and 3).
The components of MUPAAC system, as reported in Fig.2, are:

- **PC (Personal Computer): a personal computer which in practical is the user interface of the entire system and the interface towards other areas by means of a Fast Ethernet network. It sends/receives messages to/from the actual microprocessor based systems by means of the TCP/IP-based network or a CANBUS network. For this reason PC can be endowed with a CANBUS board for interface (PC-CANBUS boar) or may present an Ethernet card.**
- **SIPC board (SED Industrial Peripheral Computer): a microprocessor based system which interprets ISO instructions coming from PC and manages their execution. The communication with the PC will be implemented by using CANBUS. SIPC also interacts with (i) the DSP-PCI boards for driving axes and receiving alarms and synchronization; (ii) the I/O boards for activating and receiving I/O signals;**
- **DSP-PCI boards: boards based on a DSP, Digital Signal Processor, for managing up to 4 axes by using an improved PID for evaluating the action of motors. For the physical (low) level, the communication between SIPC and its DSP-PCI boards will be made by using a standard PCI bus;**
- **I/O boards: boards which allow the effective acquisition and production of actions on the machine by reading/writing I/O ports. They are endowed with a microprocessor for interpreting messages sent on CANBUS which are specific commands for managing I/O ports;**
- **CANBUS: a communication support used for establishing communications: (i) between the PC and the SIPC boards, and (ii) between each SIPC and its I/O boards;**
- **PCI BUS: a communication support used by each SIPC board for communicating with its DSP-PCI boards.**
- **TCP/IP-based Network: a classical Ethernet or Fast Ethernet network based on TCP/IP. This network support is used when from the PC and SIPCs of the architecture has to pass more than a 500 Kbps.**



MUPAAC activity plans to adapt the INDEX-DSP architecture of SED. In particular, this action will consist in improving INDEX-DSP performance and functionalities by using HPCN technologies: removing the LOGIPACK, RS232, RS 485 and the dual port memory communication supports and substituting them with the more efficient mechanisms such as CANBUS and PCI protocols. The adaptation of INDEX-DSP will be an efficient support for focussing this project on technology transfer. For these reasons:

- **PC-CANBUS board will be designed and implemented;**
- **SIPC board for the prototype will be obtained by using commercial products. Its further evolution will be obtained by adapting the INDEX-DSP main board of SED, introducing SIPC-PCI interfaces. Boards for communicating with CANBUS and for Ethernet will be implemented and acquired, respectively. CANBUS board is based on PC104 interface.**
- **DSP-PCI board will be obtained by adapting the DSP board of INDEX-DSP architecture of SED by introducing the possibility of having a flexible and reconfigurable multi DSP architecture and adding a PCI interface and other features.**
- **I/O boards will be obtained by adapting I/O boards of SED introducing on these boards an I/O-CANBUS interface (substituting LOGIPACK and RS485).**
- **CANBUS: is a high-level CANBUS protocol between PC and SIPC boards as well as between SIPC and I/O boards will be defined and development.**
- **PCI BUS: is a high-level PCI protocol between SIPC and DSP-PCI boards will be defined and development.**
- **TCP/IP-based Network: is a high-level protocol based on classical API which are available for TCP/IP.**

The adaptation of INDEX-DSP hardware/software towards a multiprocessor architecture will consists in removing old parts and adding new communication supports. New functionalities due to the possibility of building a flexible distributed/parallel system for automatic control will be implemented. Therefore, software support for integrating SIPCs along the network and monitoring the network behavior will be implemented by using HPCN technology. This software will be integrated in the already mature software architecture of SED (see Fig.3). Applicative software for generating ISO programs, interpreters, resolver of logic equations, algorithms of control, interpolators, user interface and high-level end-user-oriented applicative software, etc. will be directly inherited by the SED software architecture and collection of products.

For these reasons, a great work will be performed by adapting hardware and software and by integrating the new components (communication supports) into the general architecture. The complete system will reach a greater value with respect to INDEX-DSP, since a new set of strongly innovative products with a set of new functionalities and higher performance will be implemented.
In the component section, details about the main components of MUPAAC are reported.

CANBUS: hardware and software issues

Before to discuss what will be done for this component, it is better to explain why the CANBUS network is capable of satisfying our requirements in terms of performance and thus why we have chosen to use it during the feasibility study of SED and DSI.
As previously pointed out the CANBUS is used in two parts of our architecture: for communications between the PC and the SIPCs and between SIPC and its I/O boards.

SIPC-I/O boards CANBUS: hardware and software issues

The connection between SIPC and its I/O boards must provide a band large enough to guarantee a refresh time <= 10 msec for all I/O ports. This is good value for high performance CNC based systems.
According to CANBUS low-level protocol a frame containing at most 8 bytes of data is sent by using 129 bits on the bus. For these reasons, on the basis of the previous discussion, if a system has to send 256 bits, these can be sent with 32 frames of 129 bits, for a total of 4128 bits. If a refresh time of 10 msec is chosen then 413 Kbps are needed. The maximum throughput of the CANBUS is equal to 1 Mbps, which satisfies the above extreme conditions. Please note that a higher value of bits could be transmitted by using a higher value of refresh time -- e.g., with 15 msec and the same throughput 384 bits can be refreshed.
For this reason, CANBUS or an other bus having the same or better performance is suitable for a system like MUPAAC which requires the above mentioned number of I/O ports; moreover, CANBUS is the cheapest bus in the category. It is also very open since hardware for its implementation is distributed by several vendors, and software is public (see http://www.omegas.co.uk/can, http://www.ba-karlsruhe.de/automation, http://www.csv.warwick.ac.uk, etc.). The use of CANBUS represents an improvement for INDEX-DSP, where the connection between the master board and I/Os is made by a LOGIPACK (a SED proprietary parallel bus) or by means of RS485. A reason for eliminating:

- **LOGIPACK is the fact that it is a parallel bus which is fast enough but it is not capable of reaching high distances, while**
- **RS485 is too slow to support the refresh in time the required number of I/O ports even if it can be used for longer distances with respect to LOGIPACK.**

For communicating between SIPC and I/O boards a specific high-level protocol will be implemented. At lower level, in order to improve CANBUS robustness special CANBUS chips which include the automatic correction of errors (resending and controlling local addresses) will be used. It will be light as possible. The protocol will be defined partially reusing those defined for LOGIPACK and RS485 in the INDEX-DSP.
The CANBUS board for SIPC will be implemented for plugging it on the PC104 bus of the mother board. The PC104 is in practical an ISA bus on an industrial connector.
With the aim to obtain the communication through CANBUS channel, between SIPC card and the I/O modules, it will be necessary to plan and to construct a CANBUS card with bus PC104. In this phase of development of the project, it has been thought that the CANBUS PC104 card does not have to have a CPU of support to the Intel 82527 chip for the communication on this serial bus.
Since the total throughput of the system can be heavily influenced from this type of realization, in a more advanced phase this point will be

reexamined. During this second step of the planning it will be estimated if could be necessary that the PC104 CANBUS card should have also a 80188 CPU, that will concur to leave free the elaboration, and the preparation of the packages to send on CANBUS channel from the CPU of the SIPC.

CANBUS I/O structure:

To obtain a flexible I/O apparatus and to decrease the costs of the total system, it has been considered to realize a device formed from a CPU module with a CANBUS connection channel, and specialist modules connected with the CPU through a SPI channel. This solution allows to obtain I/O devices that follow the necessities of the customer in the more tight way.

PC-SIPC boards CANBUS: hardware and software issues

This connection is mainly used for sending ISO programs to SIPC boards and for exchanging high-level controls among the SIPCs of the architecture.
The workload of this communication support is quite low. For the typical applications in which SED automatic controls are used, an ISO program for 4 axes machines of 250 Kbytes is consumed by the machine/controller in about 15 minutes. This means that a load of 277 bytes per second for each DSP-PCI board with 4 axes is needed. If a SIPC manages 8 DSP-PCI boards with 4 axes each SIPC has to acquire from PC 2216 bytes per second. These are sent on the CANBUS by using frames of 129 bits containing 8 bytes each; thus 277 frames, 35 Kbps are needed. This means that the PC-SIPC CANBUS can support even 12 SIPC boards. In effect, this limit is high since that channel is used also for reporting alarms to the main station and for exchanging messages and synchronization among SIPCs. For these reasons, we intend to limit the number of SIPC boards to 10.
The increased number of axes which are present on a pipeline of production and the increased speed of CNCs (for satisfy requests of machine builders) require a corresponding increment in speed of the communications; thus a CANBUS has been preferred rather to maintain the serial communication of INDEX-DSP.
Also in this case, for communicating between PC and SIPCs a specific high-level protocol will be implemented. It will be light as possible. In order to improve CANBUS robustness special CANBUS chips which include the correction of errors will be used.
As a conclusion, CANBUS was chosen because it has a maximum bit rate of 1 Mbps which is satisfactory for the above described applications. Moreover CANBUS is not expensive since the related information is public and many vendors of CANBUS chips are present (the basic software is also public). Please note that, it has been chosen as a support for communicating between PC and SIPCs and between SIPC and I/O boards for saving money in implementing CANBUS interfaces and related software.
Moreover the CANBUS between the PC and SIPC can be substituted with an Ethernet network when the bandwidth required is greater than 500Kbs. In that case the Ethernet card are commercial boards.

Low-Level Protocol for CANBUS

The Controller Area Network (CAN) is a serial communications protocol that efficiently supports distributed real-time control with a very high level of security.
Its domain of application ranges from high speed networks to low cost multiplex wiring.
In automotive electronics, engine control units, sensors, etc. are connected using CAN with bit rates up to 1Mbit/s.
To achieve design transparency and implementation flexibility CAN has been subdivided into different layers:

- **the (CAN-)object layer**

the (CAN-)transfer layer

- the physical layer

The object layer and the transfer layer comprise all services and functions of the data link layer defined by the ISO/OSI model.
The scope of the object layer includes:

- finding which messages are to be transmitted
- deciding which messages are received by the transfer layer actually
- providing an interface to the application layer related hardware

The scope of the transfer layer mainly is the transfer protocol, i.e. controlling framing arbitration, error checking, error signaling, fault confinement. Within the transfer layer it is decided whether the bus is free for starting a new transmission or whether a reception is just starting. Also some general features of the bit timing are regarded as part of the transfer layer.
The scope of the physical layer is the actual transfer of the bits between the different nodes with respect to all electrical properties. Within one network physical layer, of course, has to be the same for all nodes.
CAN has the following properties:

- prioritization of messages
- guarantee of latency times
- configuration flexibility
- multicast reception with time synchronization
- system wide data consistency
- multi-master
- error detection and signaling
- automatic retransmission of corrupted messages as soon as the bus idle again
- distinction between temporary errors and permanent failures of nodes and autonomous switching off of defect nodes

Layered structure of a CAN node:

Application Layer
Object Layer
Transfer Layer
Physical Layer

The Intel 82527 chip was chosen for our CAN module and it will realize the physical, transfer and object layer of this structure.
The CAN system it is based on a packetized communication, there was four frame type:

- DATA Frame

- **REMOTE Frame**
- **ERROR Frame**
- **OVERLOAD Frame**

Only the DATA frame is visible from the application layer.

High-Level Protocol for CANBUS

In order to resolve the application layer protocol it was analyzed the following standard protocol:

- **Smart Distributed System (SDS) from Honeywell**
- **CAN Open from Can in Automation (CiA)**
- **DeviceNet ODVA from Rockwell**

From these standard protocols for the application layer, it was chosen the SDS one.
The SDS protocol was the smallest, the simplest, and will satisfied all the needs for the applications that will be developed with this CAN bus system.
A SDS Network consists of physical components that may be inputs, outputs, PLC interfaces, etc. Physical components are modeled as collections of logical devices that communicate over a physical medium.
The SDS system supports real-time controls, diagnostics and configuration functions for digital and digitized analog, for sensors (inputs) and actuators (outputs). It supports event driven, timed and polled communication modes.
The simplest communication model supported by SDS is the Master/Slaves communication, where the Master device uses the I/O services provided by the Slave devices. The Master views each Slave device as an object with:

- **a set of Attributes that may be read or written;**
- **a set of Actions that may be called;**
- **a set of Events that the device may generate.**

A Slave device is identified by:

- **Device Address (6bit);**
- **EOID (Embedded Object Identifier) (4bit);**

The SDS application layer provides services tailored for the maximum support of a distributed network within the limitations of the CAN Data Link Layer.
The following Application Layer services are available.

Service	**Function**
Read	**Allows ALP (Appl.Layer Protocol) service to read**

	a value of a device object
Write	Allows the ALP service user to modify the value of a device object
Event	Allows an ALP service user to report a device object event
Action	Allows an ALP service user to command a device obj. to execute an action
COS ON	Specialized event services that a reports a change of state to the ON state
COS OFF	Specialized event services that a reports a change of state to the OFF state
Write ON	Specialized write services that a writes an ON state to a device
Write OFF	Specialized write services that a writes an OFF state to a device
Connection	Allows the ALP service user to open/close individual logical addr. connections
Channel	Allows the ALP service user to establish and use Multicast and Peer-to-Peer channels

The SDS service model uses four primitive functions: Request, Response, Indication and Confirm, to provide the Application Layer services. When an initiating device invoke an application layer service (such as the "read" service), the following sequence of events occurs.

- **The request primitive is presented to the Application Layer.**
- **The application layer generates an Application Layer Protocol Data Unit (APDU) to be processed by the Responding Device?s application layer.**
- **The Application Layer issues a send message request to the CAN Data Link Layer using the APDU.**
- **The Data Link Layer prepares a CAN-formatted Protocol Data Unit (PDU) and presents it a bit at a time to the Physical Layer for sending to the Responding Device.**
- **The indication primitive represents the requested service as it is received at the Responding Device?s application layer.**

The Responding Service User creates a response to the read request.

- **The response primitive conveys the information from the Responding Device.**
- **The confirm primitive notifies the Initiating Device that the response has been received.**

The Mupaac implementation of the Smart Distributed Systems Service Model is a reduced implementation of the full SDS protocol, it uses all the four primitive functions: Request, Response, Indication, Confirm. All two service conventions are implemented: Basic and Fragmented.
In Mupaac-SDS are implemented only three Application Layer services:

- **READ**
- **WRITE**
- **ACTION**

READ Service

The Read Service is used to read an attribute value of an Embedded object. For example, this service could be used to read the present value of a sensor.

WRITE Service

The Write Service is used to modify an attribute of an Embedded object. For example, this service could be used to set an actuator output to on or off.

ACTION Service

The Action Service is used to execute the actions specified for an Embedded object. For example, this service could be used to move an axis to a target position.

PCI BUS: hardware and software issues

Before to discuss what will be done for the PCI bus, it is better to explain why the PCI is capable of satisfying our requirements in terms of performance and thus why we have chosen to use it.
The main data exchange between SIPC and DSP boards is due to the passing of macropoints to DSP-PCI boards. As previously stated the maximum number of DSP-PCI boards is not fixed, since it depends on the performance required by DSP-PCI boards.
For example, if a system presents 32 axes at least 4 DSP-PCI boards must be used (no more than 8 axes per board), with a refresh time = 500 micro sec. A faster refresh time can be obtained by increasing the number of DSP-PCI boards: 8 DSP-PCI boards with 4 axes and a refresh time of 250 micro sec.
From the point of view of the communication between PC and DSP-PCI boards, if an architecture with 8 DSP-PCI boards with 4 axes each is chosen, then the SIPC has to pessimistically send about 400 bytes to each DSP board and to receive back about 100 bytes (error values, signals of synchronization, etc.). In the 400 bytes the macropoints, the parameters of trajectory, etc. Thus 500 bytes for each board every 250 micro sec leads

to need 2 Mbytes per seconds per DSP board. If 8 DSP boards are present, then 16 Mbytes of throughput are needed.
In the above cases, the PCI bus has no problems, since it can reach without any problems even 33 Mbytes per second in burst mode (by using the right chip set). Moreover, the use of PCI in industrial context is rapidly growing (see Ventura Development review), and it is reasonable that it will become in few years the most commonly used bus. The DSP chip on DSP-PCI board will be interfaced to PCI bus by using a dual memory.
Therefore, we have 125 byte/axis to transfer, a minimum refresh time of 125 micro sec and a maximum of 20 Mbytes per second of throughput for the PCI (see next Section).
Please note that if more complex interpolation mechanisms will be used in MUPAAC systems a maximum of 1 Kbytes of data for each board will be required (e.g., cubic splines, nurbs, B-splines), then 4 Mbytes per second will be needed. In this case there are two possibilities:

- **the reduction of the number of axes per DSP board, or**
- **the reduction of the number of DSP boards for SIPC.**

Both these solutions are possible since MUPAAC architecture is flexible as it is shown in the next subsection.

High Level PCI Protocol

The protocol used for communication of the SIPC and the DSP boards is simple and efficient. The DSP-PCI interface provides a memory mapped common data region, this region is subdivided in two parts. One is used for communication from SIPC to DSP and the other for communication from DSP to SIPC.
Since the common memory is of 32KB, and 16KB is used for transferring messages in one sense and the other 16KB for the other sense one message may be approximately up to 16KB long. The subdivision of the memory in two equal parts may be changed if during test phases will be seen that different amount of memory are needed.
The communication is handled through interrupts; there are two specific location in the common memory that when they are accessed generate interrupts one to the SIPC and one to the DSP.
The communication protocol for transmission of the message from the SIPC to the DSP is:

1. **The SIPC writes the message in the SIPC2DSP memory zone at a specific address (every board has a different address).**
2. **The SIPC accesses to the location to generate the interrupt to the DSP.**
3. **The DSP when receives an interrupt reads the message.**
4. **The DSP produces an ACK message in the DSP2SIPC memory zone at a specific address.**
5. **The DSP accesses to the location to generate the interrupt to the SIPC.**
6. **When the SIPC receives the interrupt for an ACK message the communication is ended with success. If the interrupt is not received within a certain time-out the interrupt to the DSP is regenerated and this procedure is repeated for a maximum number of times after which the communication is ended with fault.**

The other type of communication is perfectly symmetric.
The communication protocol for trasmission messages between SIPC and DSPs can be syncronous or asyncronous, there are some messages that not require an ACK message. For example, when the DSP has executed all the instruction, the DSP sends an interrupt to SIPC to indicate the end of instruction. The SIPC when receives this type of interrupt decides to send new instruction (if there are other instruction to execute) or if there aren't instruction don't answer.

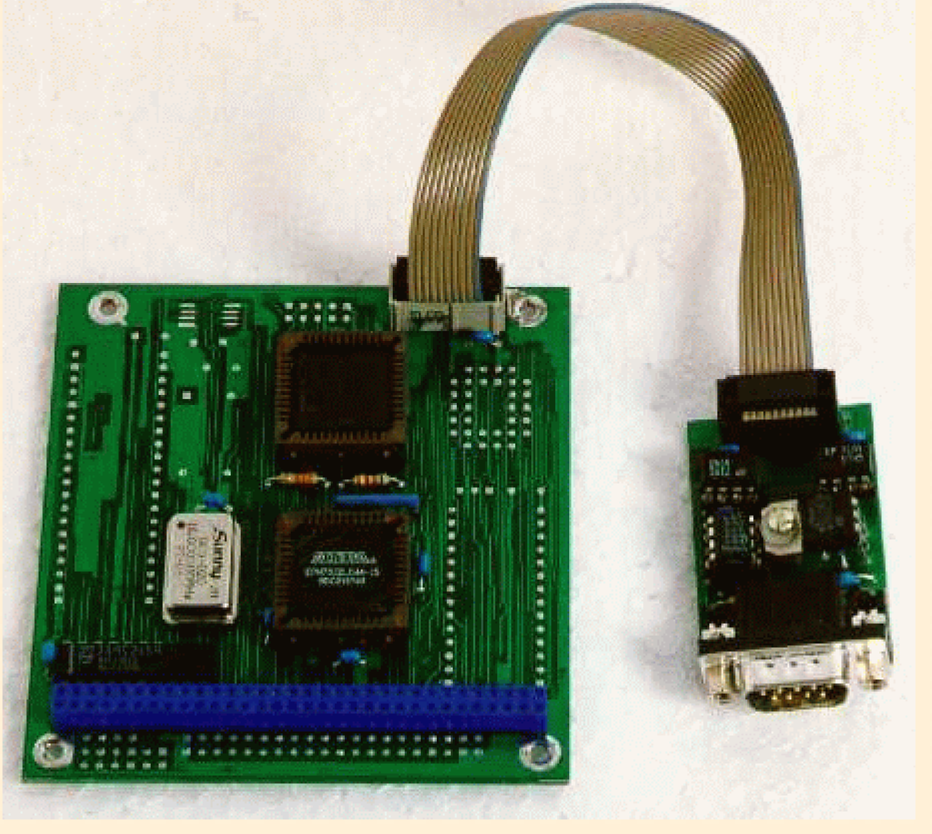
Details about MUPAAC Components

PC-CANBUS board

PC-CANBUS board will be built for EISA bus, PC104. This board will be installed in the PC machine, which is used (i) to enter the ISO program, (ii) supervising the work of the several SIPC boards which can be present on the network, and (iii) connecting the area to other areas by means of and Ethernet network.

The PC is also the main user interface of the system. The PC is connected with at least a SIPC, and sends commands to it, but also receives information and alarms from it. The PC is a commercial industrial personal computer endowed with EISA bus, PC104.

When the architecture requires to communicate to the SIPCs of the architecture more than 500 Kbs this board is substituted with an Ethernet at 10 Mbps of 100 Mbps depending on the requirements.



SIPC board

SIPC board is the most important component of MUPAAC system. In fact, its services are:

Reception and interpretation of ISO instructions sent by the PC. On the basis of the program received, SIPC manages all other devices which compose the CNC: DSP-PCI boards (i.e., axes) and I/O boards (i.e., I/O ports). SIPC also sends information to PC for synchronising other SIPCs and for advertising of the presence of alarms.

- Transmission of elaborated information to each DSP-PCI board:
- macropoints and data useful to calculate micropoints (by means of interpolation),
- control commands, and
- other general parameters.

Moreover, each DSP-PCI board returns reference coordinates to SIPC for synchronization with other axes and alarms.

- Resolving logic equations and:
- producing messages to input boards and ports, and
- acquiring data from output boards and ports.

Therefore, SIPC board could present

- two CANBUS interfaces and one PCI interface, or
- a CANBUS interface and an Ethernet interface and a PCI interface.

The SIPC board presents: a CPU (Intel Pentium, or Pentium pro), main memory (from 8 to 32 Mbytes of RAM), EPROMs for bootstrap and containing the specific software, 1-2 CANBUS interfaces, a PCI interface (called SIPC-PCI interface), a specific local bus for connecting this board to a video adapter, a keyboard, an RS232, a disks, and optionally an Ethernet board, etc., for allowing the full test and debug. The operative system has to be a specific ROMable kernel as in the present INDEX-DSP architecture.

Please note that, differently from INDEX-DSP main board, the SIPC can be connected with more than one DSP-PCI board. The maximum number of DSP-PCI boards for each SIPC depends on the throughput of PCI network and on the request of data of these DSP-PCI boards. For example, a typical SIPC has 4 DSP-PCI boards for managing at most 16 axes simultaneously (4 axes for each DSP-PCI board). The SIPC must manage a greater number of I/O ports than INDEX-DSP (max 8 axis on a single DSP board and max 60 I/O ports for all). It is reasonable that a CNC system needs about 5 bits (I/O ports) per axis, thus MUPAAC will manage about 40 bits (5 times 8) of I/O for each PCI-DSP board installed. If 4 DSP-PCI boards with 8 axes each are installed, thus 160 bits are needed. In certain cases, also other types of I/O ports can be needed, for example bytes, analog data, etc. In general, no more than 256 bits are needed in the above conditions.

Another limitation for the SIPC board is the number of the so-called blocks to be generated on basis of the ISO instruction interpreter and macropoints generator (see Fig.3). For an 80486 DX2 66 the number of blocks processed per second is about 300, these are enough for satisfying the needs of 8 axes at 250 micro sec or 4 axes at 125 micro sec and so on. MUPAAC will provide a stronger microprocessor (e.g., Pentium Pro 200 Mhz) thus SIPC board will be capable of processing at least 1200 blocks per second.

Card SIPC is the controller of system MUPAAC. The aim of this project is to obtain a high performance architecture for control at low costs. For these reasons, it has been decided to use of the microprocessors of the family Intel Pentium. The realization of a mother board, that supports that kind of microprocessors, is a time consuming project. It is faithfully for the capacity of the team of MUPAAC, but obviously out of the scope of this specific Activity which is mainly devoted to exploit HPCN technology. For these reasons, and in order to reach the objectives proposed: for producing a prototype in few months we decided to implement SIPC board to get material from the market. According to the Exploitation Plan, once obtained and tested the MUPAAC prototype a specific SED mother board will be built -- that is, after the completion of project.

In the market there exists several boards that can be profitably used as SIPC -- e.g., MITAC, INSIDE, AMD. More specifically these are simply PC boards for passive bus. They have to be considered a full SIPC only when they present the PC-CANBUS board the related software as discussed above.

In particular, the SIPC board has to provide a PCI interface and a PC104 bus, obviously memory etc. The PC 104 is used for expanding memory, Ethernet card, for the PC-CANBUS board, for the optional graphic user interface, etc.

It has been chosen to use a Ethernet protocol between Pc and the several subsystems, so as to be able to obtain a twofold advantage, a wider bandwidth regarding the plan originally previewed with only a CANBUS. This solution is also much more interesting for the purchasers that have an already installed Ethernet network in the factory. The use of the Ethernet for connecting subsystems will allow to have a lower price for the total system, and therefore a wider spread of the product.

DSP-PCI board

A DSP-PCI board is responsible for the coordination of the motions of at most 4 axes. This maximum number of axes depends on the number of analog input and output ports which are directly managed by the DSP-PCI board for providing the action on motors and the reading of sensors (i.e., position, velocity, etc.). Each DSP-PCI board provides the following services:

- reception of commands from SIPC board by means of the DSP-PCI interface;
- the calculation of micropoints. This is done interpolating macropoints sent by SIPC board; as in INDEX-DSP, three interpolation types (linear, circular and spline) will be available on MUPAAC. The DSP-PCI board uses micropoints to evaluate action values for axes (using specific analog outputs which are placed directly on DSP-PCI board), in order to produce the required trajectory;
- evaluation of the actions for the motors of axes on the basis of the data read by means of specific analog inputs ports. The control is based on PID (Proportional Integrative and Derivative) algorithm plus additional filters for reducing problems due to machine characteristics (these are need to allow the reaching of high velocity and precision).

These elaborations require a high calculation power; as in INDEX-DSP, a DSP will be used (Analog Device AD 2181) (DSP offers high speed at low cost). The other parts of these boards (for example axes control) will be fully derived from those of INDEX-DSP. The PCI interface will substitute a method based on dual memory implemented in INDEX-DSP where only one DSP board for main board is allowed.

DSP-PCI board will be capable of evaluating action values for axes every 250 micro sec (if 4 axes interpolated are used); lower or higher values could be set when performance required are higher or lower, respectively. For example, limit values will be 500 micro sec for 8 axes, 125 micro sec for 2 axes. As conclusion, the limit of this board is = 125 micro sec and the number of axes <= 8 axes. Moreover, the ratio between the refresh time and the number of axes (T/NA see Tab.1) must be = 62.5 (micro sec per axis); thus 1000 micro sec for 8 axes is allowed. Other examples of complete configurations will be given later.

This board is the core of the hardware of the project. In fact this board has to control the correct positions of axes of the connected machines. For the choice of the microprocessor to be used in the DSP-board, three DSPs have been evaluated. The choice has been limited to these DSPs since the power required and the dimension of the memory required do not leave space to add more DSPs:

- Motorola 5630x
- Texas Instruments TI320C3x
- Analog Device AD2106x (SHARC)

The Motorola's chip, is the only one (of the three) with a built-in interface to the PCI bus, but it has been discarded because it does not provide a floating-point unit. The experience made with the INDEX-DSP project suggested that all components without a floating-point unit should be avoided.

The choice between the chips of Texas and of Analog Device, has selected the Analog Device processor although it has a greater price. The main reasons for this choice are as follow:

- A greater power of calculation; The Analog's DSP has a power of 120 Mflops whereas the Texas's DSP has ``only'' 60 Mflops.
- A more reliable evolution since it has been recently proposed;
- High flexibility in its use. The development toolkit of the Analog Device DSP is simpler to be used with respect to that of Texas.

The selection has been made on the basis of objective experience since DIE has a direct experience on TEXAS DSPs while DSI and SED have a direct experience on Analog Device DSPs.

More discussions, tests and benchmarks have shown that the difference, in terms of performance is greater than that shown by the simple velocity index introduced above. The greater performance of the Analog's chip follow from its capacity to compute the same program with a number of elementary instructions lower than those used by the Texas's chip.

The Texas components family is on the market from many years, in 1997 Texas presented a new component (not yet available) with technical characteristics better than those of the TI320c3x family, but with a price that will be similar. This could lead Texas Instruments to abandon the production of the more obsolete component.

For the MUPAAC project seems that the large serie production could not begin before two years (one year for design and realization, one year for the introduction of the new product in the market). For SED should be a great damage if after to have planned and realized a system based on the TI320c3x, this came removed from the market.

On the contrary the Analog's DSP has been presented recently. Moreover, Analog Device is developing new products on the same line, for this reason seems that we can expect a product stability for more years. Moreover the relative youth of SHARC can lead to suppose, with reasonable security, a decreasing price.

The last reason, but not the least important for the choice of the DSP, has been its scalability. In fact the SHARC family is composed of three chips, all pin-to-pin compatible. For this characteristic a board based on these family can be easily adapted to different needs.

For these reasons has been decided to use for the DSP-PCI board a microprocessor of the AD2106x family, in particular to the current state of the market, the AD21061 seems to be the best choice for our needs.

On the base of the experience made with the INDEX-DSP project, seems that can be sufficient 256 Kbyte of RAM memory, besides those already present on the AD21061 (128Kbyte).

The interface between the DSP board and the board named SIPC through the PCI bus will be made with a double port memory with 32 bit parallelism and a deep of 2 Kbyte.

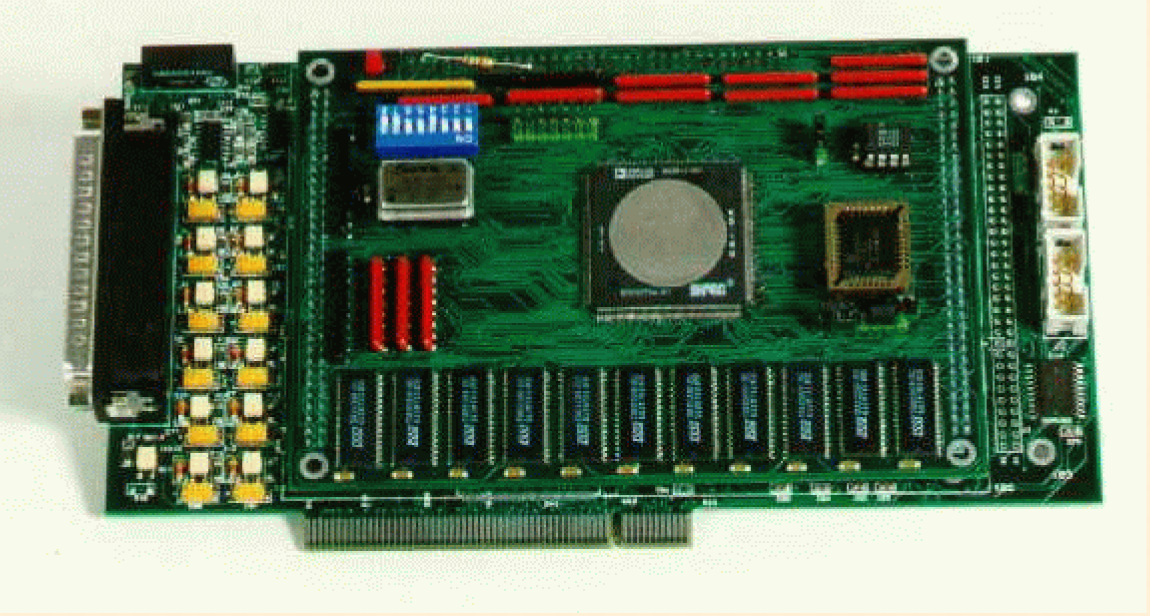
Moreover, an EPROM memory of 512 Kbyte is needed for the code and an EEPROM memory of 32 Kbyte to save some parameters of the axes managed by the board. For the EPROM and EPROM will be used memories with 8 bit parallelism, since the access to these memories does not influence the overall performance of the machine.

Since the DSP-PCI board has to control four axes, it needs four D/A converters. The DACs selected have 6 bits of resolution, a such high resolution is due to the necessity to obtain a system that uses all the potential calculus capacity that the machine offers.

For the interface with the encoders, the needed logical functions will be made with an EPLD, this is mainly due to economic reasons, with respect to the use of specialized components.

To obtain a great flexibility for the system, on the DSP-PCI board, also four A/D converters with 10 bit resolution, a RS232 serial port, a CANBus communication channel, four digital outputs and eight digital inputs have been included.

The interface between the DSP and the PCI bus will be realized through the implementation of the needed logical functions with an EPLD. This will permit to SED to obtain a deeper knowledge on the PCI bus rather than that obtainable from the use of specific chips. Moreover this will bring to a product adaptable to various needs. Another advantage is to have a product surely stable in time that has not to deal with the high variability of the PCI chip interface market.



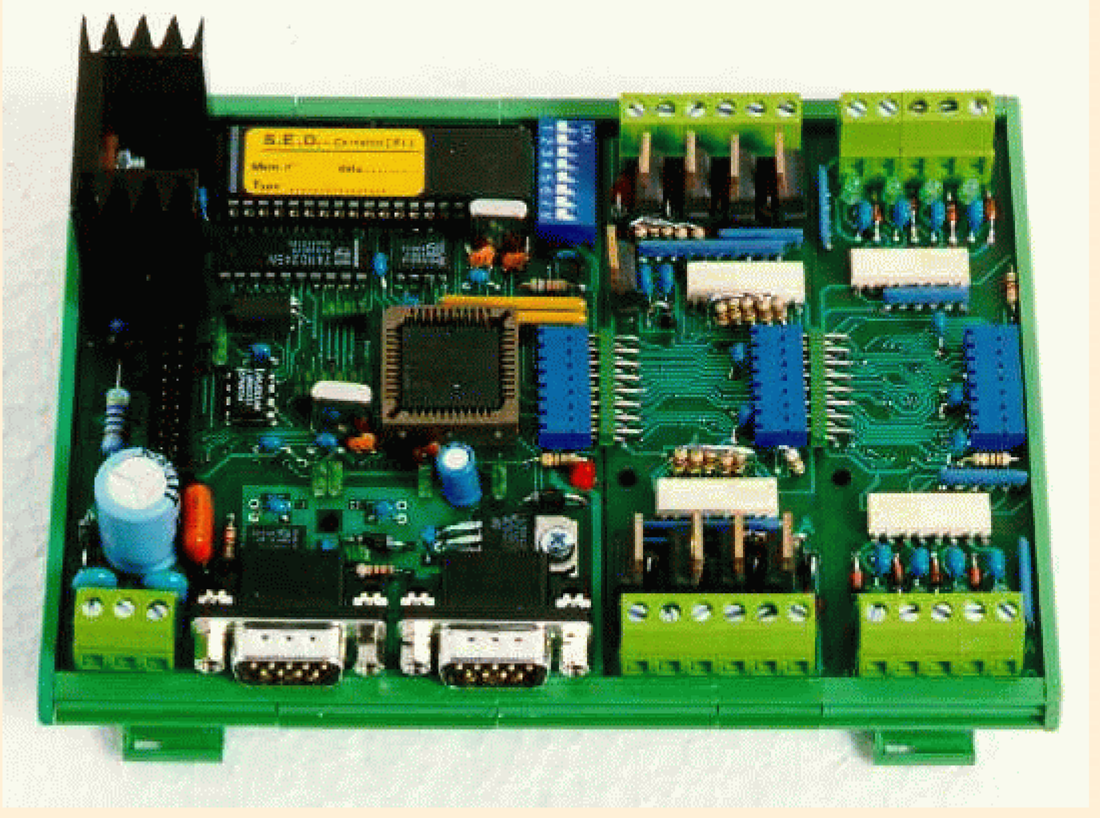
I/O Boards

These I/O boards are quite simple. They will present a very simple microprocessor for embedded system -- i.e., an Intel 8051. Its work consists in:

- receiving commands from a specific CANBUS chip and thus from SIPC via CANBUS;
- interpreting the corresponding commands;
- executing the commands which can be: read/write of the internal status, read of an input port, write of an output port.

Presently, SED produces several types of I/O boards. Examples are boards for providing: 16 digital inputs and 16 digital outputs, 8 digital inputs and 8 digital outputs, 32 digital inputs, 32 digital outputs, 16 analog inputs (12 bits), 32 analog inputs (8 bits), 4 analog inputs (16 bits), 16 analog output (12 bits), etc. Digital and analog ports are available with different voltages, with and without isolation, etc.

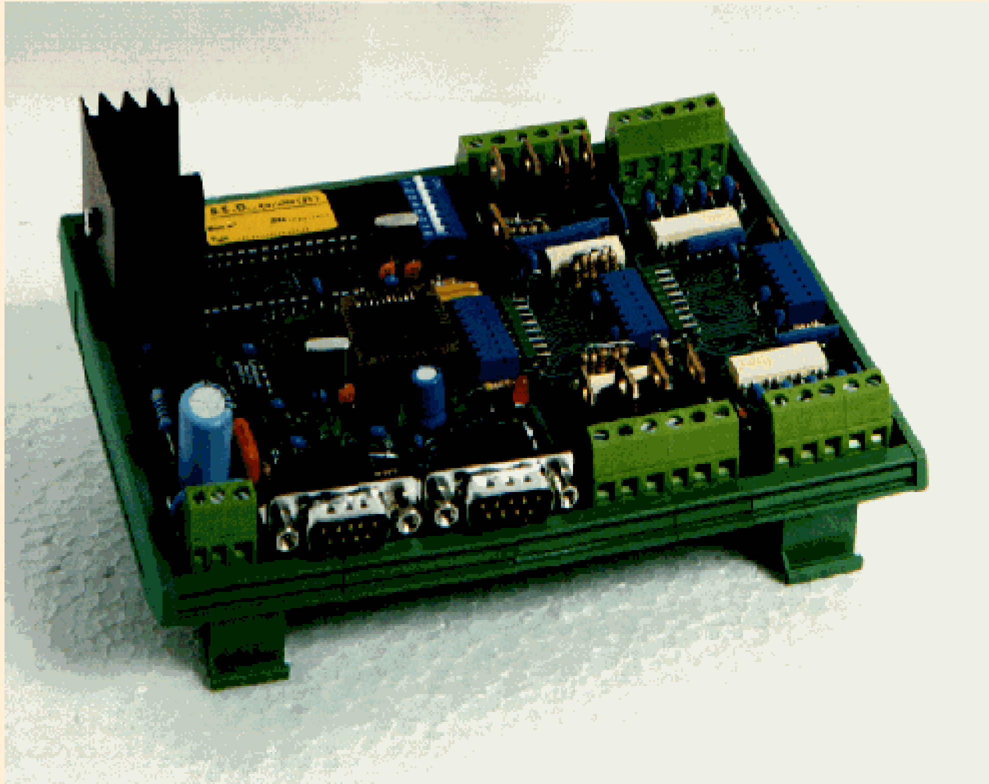
Two kinds of CANBUS modules will be produced: one provided of a CPU while the second will be completely passive.



I/O CANBUS module with CPU

This module could be realized with a cpu of low price (Intel 8051) for the realization of modules with a limited needs of calculation power, or with a more powerful microprocessor (Hitachi SH7000), in the case the customer needs to manage many modules in complex configurations.

An example of an I/O canbus module is shown in the picture below.



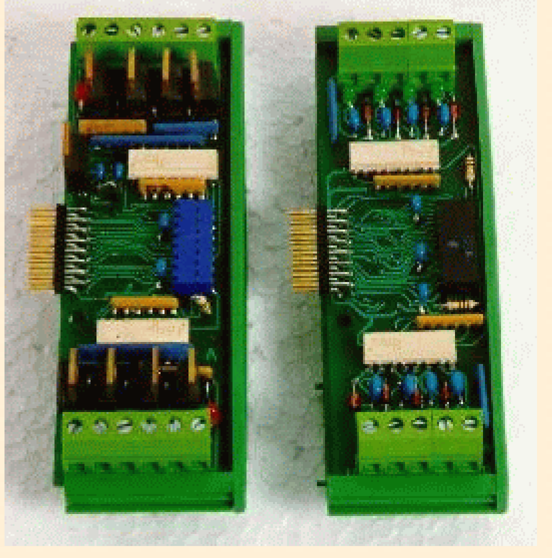
It is composed of:

- A CPU Intel C51 (a very low cost CPU);
- A SPI-module with 8 digital OUTPUT;
- An SPI-module with 8 digital INPUT TTL.

We can add many other modules like analogic input, output with relais, counter or monoaxes controller.

I/O CANBUS modules

Inputs/Outputs
8 digital inputs 24 V a.c.
8 digital outputs with relays
8 digital inputs 24 V c.c.
8 digital outputs with transistor
Converters
1 A/D converter 12 bit multichannel
1 A/D converter 12 bit monochannel conditioned
Various
1 counter with 2/4 channels 32 bit
1 module for the management of single axis



Flexibility of MUPAAC

As a conclusion the main differences between INDEX-DSP and MUPAAC architecture are summarized in Tab.1.

Features	INDEX-DSP	MUPAAC
SIPC-DSP communication	shared memory	PCI
PS-SIPC communication	RS 232	CANBUS
SIPC-I/O communication	Logipack, RS485	CANBUS
maximum number of main boards	1	10 SIPC boards
maximum number of DSP boards	1	depending on performance
maximum number of axes per DSP board	8	8
minimun refresh time for 2 axes	125 microsec	125 micros
minimun refresh time for I/O	15 millisec	10 millisec
control algorithm	PID	PID

Tab. 1: INDEX-DSP vs MUPAAC, limits and features

In Tab.2 a set of possible configurations of MUPAAC architecture are presented. The configurations present from 4 to 128 axes and performance from 125 to 1000 microsec as period for updating actions of control on axes. Lower performance are also possible but they are out of the goal of MUPAAC architecture as previously stated.

Case	# Ax	Ref. Ax.	T/NA	# DSP	# Ax/DSP	PCI B	Block/s	#SIPC	#DSP/SIPC	C
1	4	125	31.25	2	2	4	600	1	2	4 (2+2)
2	4	250	62.5	1	4	2	300	1	1	2 (2+1)
3	4	500	125	1	4	1	150	1	1	2 (2+1)
4	4	1000	250	1	4	0.5	75	1	1	2 (2+1)
5	4	2000	500	1	4	0.25	37.5	1	1	2 (2+1)
6	8	125	15.62	4	2	8	1200	1	4	6 (2+4)
7	8	250	31.25	2	4	4	600	1	2	4 (2+2)
8	8	500	62.5	1	8	2	300	1	1	2 (2+1)
9	8	1000	125	1	8	1	150	1	1	2 (2+1)
10	8	2000	250	1	8	0.5	75	1	1	2 (2+1)

11	16	125	7.81	8	2	16	2400	2	4	12 (8+4)
12	16	250	15.62	4	4	8	1200	1	4	6 (4+2)
13	16	500	31.25	2	8	4	600	1	2	4 (2+2)
14	16	1000	62.5	2	8	2	300	1	2	4 (2+2)
15	16	2000	125	2	8	1	150	1	2	4 (2+2)
16	32	125	3.9	16	2	32	4800	4	4	24 (8+16)
17	32	250	7.81	8	4	16	2400	2	4	12 (4+8)
18	32	500	15.62	4	8	8	1200	1	4	6 (2+4)
19	32	1000	31.25	4	8	4	600	1	4	6 (2+4)
20	32	2000	62.5	4	8	2	300	1	4	6 (2+4)
21	64	125	1.95	32	2	64	9600	8	4	48 (16+32)
22	64	250	3.9	16	4	32	4800	4	4	24 (8+16)
23	64	500	7.81	8	8	16	2400	2	4	12 (4+8)
24	64	1000	15.62	8	8	8	1200	1	8 NP	10 (2+8)
25	64	2000	31.25	8	8	4	600	1	8 NP	10 (2+8)
26	128	125	0.97	64	2	128	19200	16	4	96 (32+64)
27	128	250	1.95	32	4	64	9600	8	4	48 (16+32)
28	128	500	3.9	16	8	32	4800	4	4	24 (8+16)
29	128	1000	7.81	16	8	16	2400	2	8 NP	20 (4+16)
30	128	2000	15.62	16	8	8	1200	1	16 NP	18 (2+16)

Tab.2: #Ax. is the number of axes of the system; Ref.Ax. is the refresh time in microsec for evaluating the action on axes; T/NA is the ratio Ref.Ax/#Ax; #Ax/DSP is the number of axes per DSP-PCI board; #DSP is the number of DSP-PCI boards in the whole system; PCI B is the general throughput on PCI in Mbytes per second which is evaluated considering 125 bytes/axes multiplied by #Ax. and divided by Ref.Ax. in microsec; Blocks/s is the number of blocks which have to be processed per second; #SIPC is the number of SIPC boards with #DSP/SIPC DSP-PCI boards each; #DSP/SIPC is the number of DSP-PCI boards for each SIPC board (#DSP/#SIPC); and C is a cost factor evaluated considering the cost of SIPC double with respect to that of DSP-PCI board.

Please note that in Tab.2: #DSP is evaluated considering also that each DSP-PCI board can support at most 8 axes, #SIPC is evaluated considering that PCI bus can support at most 16 Mbytes per second and each SIPC can produce at most 1200 blocks per second.
As it has been shown the MUPAAC architecture is flexible since can be fully reconfigured for satisfying the requirements of the pipeline of production. If can be suitable for covering both low level architectures (at low cost) and high performance control networks. Moreover, additional axes, DSP-PCI boards, SIPC boards can be added/removed when needed/unuseful. Obviously, all inter-medium configurations in which different DSP-PCI boards work by using different values of Ref.Ax. are possible according to the machine under control.
As it can be observed by column C of cost index (which can be obviously considered also a price index) the cost is directly proportional to (T/NA)^{-1} factor. This can be also considered a measure of the performance required by the automatic control, lower values are related with higher performance which is linear with the number of axes. The above presented progression for the cost/price is linear with the performance while the

others control builders present a geometric progression of price with the increment of performance. Moreover, C presents also a linear behavior with the number of axes for high performance configurations while for low performance configurations (2000 Ref.Ax.) the cost per axis decreases with the number of the axes. For these reasons, the final price for medium and high performance MUPAAC configurations will be lower than those which have been reported for the other similar solutions.
Also INDEX-DSP presents a geometric progression of cost/price with the increment of this (T/NA)^{-1} factor. This is mainly due to the need of a main board every 2/4/8 axes, thus 64 axes mean at least 8 main boards. Therefore, for INDEX-DSP the cost index is obtained by using C = 3 N.Ax./2 (if Ref.Ax. is 125 microsec m only two axes can be controlled per DSP board); thus for 64 axes C=96 instead of 48 for MUPAAC. Another example: if Ref.Ax. = 1000 microsec , then C = 3 N.Ax./8 = 48 , with 8 axes for each INDEX-DSP. In these evaluations, a scale factor of 3 has been used since each INDEX-DSP control presents one main board and one DSP board. This demonstrates the strong reduction of cost/price that the HPCN technology will produce on SED products. Especially for configurations and products presenting high performance and technology.
The reduction of cost/price and the flexibility will be capable of increasing of 30 % of the number of automatic controllers sold by SED. Moreover, it is been also estimated to have an increment of 10 % for the acquiring of a new piece of market of the high-performance controller for the proposition of cheaper controllers (at the same performance) with respect to those which are available on the market.

Planned Results

The major objective of MUPAAC activity is to insert HPCN technology in SED and within the builders of several automatic machines for cutting, soldering, etc., matter in FMM and FMC working areas. These end-users are mainly SMEs in which no distributed/parallel systems for controlling their equipments are present. The adoption of HPCN technology will allow the providing of new functionalities and business benefits for both end-users (machine builders, i.e., VALIANI) and technology transfer receivers (i.e., SED). The activity has the following specific objectives:

- **introducing HPCN technology for building, on the basis of already available computerized control of SED a flexible and reconfigurable parallel/distributed system for control in order to reduce the costs/prices for the machine builders of about 20 %. The system has been considered strongly needed for (i) integrating automatic machines into pipeline of production; (ii) allowing the implementation of FMCs at low cost. The solution proposed present several technical and business benefits. The goals are obtained by**
- **reducing the cost/price of automatic controllers from 20 to 50 % depending on the performance required (compared with the currently produced controllers of SED and with those which are present on the market).**
- **reducing the costs of maintenance and running: (i) reducing the cost for reconfiguring the pipeline of production, (ii) simplifying the synchronization of machines centralizing the supervising of control.**

Dissemination and Demonstration

Disseminating the results obtained at two levels:

National

The partners will presents of their results and experiences in a public demonstration at BIAS in Milan (October 1998) for machine builders with an exhibition stand.
The partners also plan to present their work a national Fair for machine builders.
They also plan to attend some of the next events -- e.g., INTERBIMAL in Milan, IPACK-IMA, SMAU, BIMU and EMO in Milan.

European

The partners intend to demonstrate their results and experiences in 2 public presentations at SED and VALIANI in Certaldo Florence.
The partners also plan to present their results at the European Fair SACA, and attend/present results to International Fair Elektronica of Monaco, Hannover Messe, Manufacturing Week UK, etc.

Up to July 1998, MUPAAC consortium is ready to give you any kind of technical demonstration in Florence, please contact Project Coordinator.

MUPAAC's Consortium

The consortium includes 5 Partners:

- **SED, SED of Certaldo, Prime Contractor and receiver of HPCN technology transfer (Carlo Bruni, Project Coordinator);**
- **DSI, Dipartimento di Sistemi e Informatica, Università di Firenze, HPCN technology provider (Paolo Nesi);**
- **VALIANI, industrial firm, one of the most important builders of automatic machines for producing passpartout as end-user (Dr. Valiani);**
- **CESVIT, partner of TETRApc TTN, disseminator and project controller (Maurizio Campanai);**
- **DIE, Dipartimento di Ingegneria Elettronica, University of Florence, technology provider (Piero Tortoli).**

	SED s.r.l., Certaldo, Firenze
University of Florence,	**Dipartimento di Sistemi e Informatica (DSI)**
University of Florence,	**Dipartimento di Ingegneria Elettronica**
	Valiani S.r.l.
	CESVIT

Contact Person

Reference contact person (MUPAAC Project Coordinator):

Carlo Bruni

SED
Certaldo, Firenze, Italy

Phone: +39-55-664012
Fax: +39-55-666400

Email: c.bruni@leonet.it

The Reference TTN

For the ICCOC activity, the partners have chosen to select TTN-TETRApc as their ``reference TTN'' that proposed by CPR (Consortium Pisa Ricerche, Pisa, Italy), CESVIT and CSM. In particular, CESVIT High-Tech Agency (a no-profit agency) has been selected by ICCOC partners as the reference TTN-TETRApc site.

It should be noted that CESVIT for TTN-TETRApc activity collaborates with the Department of Systems and Informatics (DSI partner) which provides support about the technological and scientific aspects of TTN HPCN. This collaboration is very suitable since the complementary roles of CESVIT and DSI within TTN HPCN have been well-identified. CESVIT has a very high visibility and sensitiveness with respect to the market, for distribution, advertising, evaluation, etc. activities (very useful for the management of the TTN-TETRApc), while DSI provides know-how in HPCN technologies (see the enclosed bibliography and biographies, Annex 4). According to the cooperation agreement between CESVIT and DSI for the TTN-TETRApc, the scientific responsible of the CESVIT part of TTN-TETRApc is Dr. Ing. P. Nesi of DSI. Please note that he is also the coordinator of the present activity.

TTN HPCN TETRApc

ARTIC

Consorzio Pisa Ricerche

CESVIT

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Interesting WWW Related on MUPAAC

CECIMO European Committee for Co-Operation of the Machine Tool Industries

Manifacturers' Association

Italian machine Tools, Robots and Automation Manifacturers' Association

The Machine Tool Trades Association (MTTA), Metalworking Machine Tool Manufacturers' Section, London, United Kingdom

Verein Deutscher Werkzeugmaschinenfabriken eV (VDW), Frankfurt/Main, Federal Republic of Germany

Syndicat de la machine-outil, de l'assemblage et de la production associée (Symap), Nueilly-sur-Seine, France

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Integrated Multiprocessor Expandable Audio Spatialization System

An activity within TETRApc TTN, ESPRIT IV HPCN

I'M EASY is an interactive and easy to use system to simulate and produce spatial effects in real-time, saving up to 30% of the costs of a manual and/or hardware solution. I'M EASY fills a gap in the current commercial market, as it provides a device for *creating in real-time* original spatialisation efects that cannot be preencoded or prerecorded, and need to be created during the performance of live events, theater applications, interactive museum shows and entertainment parks.

Pro Audio Professionals involved in audio and multimedia installations, post-production services, and in the field of entertainment activities, including game parks, theater and outdoor events can benefit from I'M EASY audio spatialisation system.

To carry out these services, a prototype will be implemented.

Features

- Audio processing and spatialisation system
- Highly interconnected parallel network of digital signal processor (DSP)
- Advanced control of multi-channel sound
- Creation of spatialisation effects applied to external signals in real-time
- Scalable and re-configurable

I'M EASY è un sistema facile di usare ed interattivo per simulare e produrre effetti di spazializzazione in tempo reale, diminuendo del 30% dei costi di una soluzione manuale e/o hardware. I'M EASY riempie una mancanza nel mercato commerciale, offrendo un dispositivo per *creare in tempo reale* effetti originali di spazializzazione che non possono essere precodificati o preregistrati, e richiedono di essere creati durante la prestazione di spettacoli al vivo, applicazioni di teatro, mostre interattive di musei, e parchi d'intrattenimento.

I professionali nel settore Pro Audio di installazioni audio e multimedia, servizi di post produzione e nelle attività di intrattenimento, includendo parchi di gioco, teatri ed eventi all'aperto, possono trarre beneficio dal sistema di spazializzazione audio I'M EASY.

Per realizzare questi servizi, un prototipo sarà realizzato.

Caratteristiche

- Sistema di spazializzazione e processamento di audio
- Rete parallela di processori di segnali digitali (DSP)
- Controllo avanzato di suono multicanale
- Creazione di effetti di spazializzazione applicati a segnali esterni in tempo reale
- Scalabile e riconfigurabile

[HPCN Center at DSI]

Last Updated September 1, 1999 Ultimo aggiornamento 1 Settembre 1999

I'M EASY consortium

The consortium includes 7 Partners:

RIGEL/ ARTEC Group

Istituto di Ricerca per l'Industria dello Spettacolo

A & G Soluzioni Digitali

Department of Systems and Informatics University of Florence

CESVIT (High Tech Agency)

GOIGEST

RIGEL/ARTEC GROUP: ARTEC GROUP G.E.I.E./E.E.I.G., Belgium - project coordinator and HPCN technology transfer receiver (Firm).
IRIS: I.R.I.S. (Istituto di Ricerca per l'Industria dello Spettacolo), Paliano-Italy (Firm), has designed an innovative device for Digital Signal Processing, fully programmable and specially tailored for algorithms implementation, that has been realized in ASIC technology. The HPCN capability of the device has been used to design a multi-processor board for Sound Distribution and Movement (Spatialization) that can be adapted to many applications. IRIS will provide a modified board and a basic library for Algorithms implementation, bringing its long experience in Sound Synthesis techniques.

DSI: Dipartimento di Sistemi e Informatica (Department of Systems and Informatics), Università degli Studi di Firenze (University of Florence), Firenze, Italy (Technology Provider) Center for HPCN (Prof. Ing. P. Nesi).

CESVIT: CESVIT (High Tech Agency), Firenze, Italy; TETRApc-TTN (Technology. Provider) TTN partner and disseminator.

A&G: A&G Soluzioni Digitali (End-user) is a company structured on an innovative pattern, which sees technicians and musicians work together every day, dealing with audio and video production carried out with computer workstations. A&G is an exclusive distributor in Italy for Apogee Electronics, APB Tools, CEDAR for ProTools, Gallery and INA GRM products, and also an authorized reseller of AVID/Digidesign and other relevant development partners.

GOIGEST (End-user): Goigest, Milano, Italy; partner and end-users.

I'M EASY contact person

Contact Person:

Dr. Alfonso Tatarelli
Rigel Engineering S.r.l. / ARTEC GROUP G.E.I.E (prime contractor, HPCN technology consumer)
Piazza Attias, 21/C 57125 Livorno (LI) - Italy
Phone: +39 0586 21.02.22 Fax : ++39 0586 21.02.55
E- mail: tatarelli@rigel.li.it
WWW: http://www.rigel.li.it/

Paolo Nesi
DSI (Department of System and Informatics) (HPCN Technology provider)
University of Florence, Via S.Marta, 3 A , I-50139 Firenze - ITALY
tel. +39 55 47.96.523 fax: +39 55 47.96.730
e-mail: nesi@dsi.unifi.it
WWW: http://www.dsi.unifi.it/~nesi

The Reference TTN

For I'M EASY activity, partners have chosen TTN-TETRApc as their ``reference TTN'' that has been proposed by CPR (Consortium Pisa Ricerche, Pisa, Italy), CESVIT and CSM. In particular, CESVIT High-Tech Agency (a nonprofit agency) has been selected by I'M EASY partners as reference TTN-TETRApc site.

It should be noted that CESVIT for TTN-TETRApc activity collaborates with the Department of Systems and Informatics (DSI partner) that provides support about technological and scientific aspects of TTN HPCN. This collaboration is very suitable since the complementary roles of CESVIT and DSI within TTN HPCN have been well-identified. CESVIT has a very high visibility and sensitiveness with respect to the market, for activities such as distribution, advertising, evaluation, etc. (very useful for TTN-TETRApc management). DSI provides know-how in HPCN technologies. According to the cooperation agreement between CESVIT and DSI for the TTN-TETRApc, the scientific responsible of the CESVIT part of TTN-TETRApc is Dr. Eng. P. Nesi of DSI. Please note that he is also the coordinator of the present activity.

Reference to the TTN TETRApc and its related partners:

TTN HPCN TETRApc	Consorzio Pisa Ricerche
TTN HPCN TETRApc	ARTIC

I'M EASY Objectives

The major objective of I'M EASY concerns the viability of HPCN technology within a particular vertical, rich niche of the entertainment market that will have an important impact on the implementation of new concepts in theatres, orchestras, concerts, cinema, creative studios, musicians, schools of music, soloists, and disco-dance, etc. In particular, the benefits derived from the deployment of I'M EASY technology will have an important influence on professionals and industries involved in the audio and sound reproduction business in which no high performance distributed spazialization system for surround music (object sound spatialisation approach) is present. The adaptation of HPCN solutions will provide new functionalities and high performances to such a system reducing cost and the present component complexity.

Main objectives and expected results of I'MEASY project are:

1. adopting HPCN technology to improve performance and to extend capabilities of the existing design of IRIS, in order to reach a satisfying price/performance ratio;
2. introducing HPCN technology for obtaining, on the basis of already available product SPARK of IRIS, a flexible and reconfigurable parallel system for sound processing and spatialization in order to introduce new features in the commercial market. The system has been considered strongly needed for controlling multiple diffusor installations, because conventional systems, based on automated mixers and outboard equipment, can be very difficult to manage, especially with a large number of output channels;
3. deploying HPCN technology to improve performance and to decrease costs of products dedicated to multi-channel sound system management, as compared to existing products and, thus, for covering a wider market;
4. disseminating results at National and European levels.

The opening of a new market for a new product, as I'M EASY, may be interesting for a wide range of potential users and it has very few competing products in the market.

Executive Summary

I'M EASY project forms an activity within the TETRApc TTN. The activity is of type Demonstration (Task 6.23) and has a duration of 18 months.

The I'M EASY project focuses on an audio and sound processing and spatialization system based on a highly interconnected network of digital signal processors, intended for applications in the fields of entertainment and professional music; the device will be completely reconfigurable and will allow the advanced control of a multi-channel sound system to create and handle spatialization effects applied to external signals.

The targeted end-users are professionals involved in audio and multimedia installations, post-production services, and more generally in the field of entertainment activities, including game parks, theater and outdoor events.

Currently there is great interest in multichannel audio systems, but it is mainly focused on coding/decoding techniques and reproduction sound systems; the proposed system intends to fill a gap in the current commercial market, as it provides a device for creating in real-time original spatialization effects that can then be encoded as needed and reproduced on either custom or already installed sound systems.

The goal is to provide an interactive system to allow spatial effects in real-time; this is mandatory for live events, theater applications, interactive museum shows, entertainment parks, as the exact timing and temporal evolution of spatial effects may be dependent on external events and for this reason unpredictable in advance. The spatial effects cannot be preencoded or prerecorded and are required to be created in real-time.

A high-performance parallel computing architecture for sound spatialization has already been developed in the form of a single board prototype by IRIS, the SPARK board. To enter the market of professional audio business a significant improvement of capabilities is needed, mainly regarding multiple and scalable systems interconnections, and in the field of configuration and software control.

I'M EASY Business Aim

The major business aim of the I'M EASY project consists in the realisation of an innovative product based on the adoption of HPCN technology to improve performance and extend the capabilities of the single SPARK board IRIS prototype (already developed) that is unable, with the current conventional technology, to reasonably satisfy the desired price/performance ratio. The exploitation of HPCN technology has the advantage to reduce risks in the migration to a top market segment of products dedicated to multi-channel sound system management.

The strategy behind the I'M EASY initiative is extremely clear:

- Enhance the existing solution with HPCN approach
- Offer new functionality not allowed to existing products currently commercialised by European and US, as well as Japanese industries
- Reduce the ratio performance price/performance dramatically
- Produce patent(s)
- Impose, in this vertical market, an industrial leadership based on a concrete use of HPCN potential

Industrial Benefits

For evaluating the end-user benefits (i.e., post-producers, directors theatres, etc.), it can be estimated that:

- the price of a typical I'M EASY system (hardware and software) will be about 3,5 KECUs. This price is about 40 % less with respect to the other audio and sound reproduction builders,

- a rehearsal can take place any time and for every single song just only because the artist needs, causing a lot of time wasted for new setups. A music production usually keeps 5-6 versions for each song before ``cutting'' the final master. Using I'M EASY leads to save up to 7.200 ECU's per production/album,

- a professional post-production studio (which can also develop audio for multimedia) costs 150 ECU's per hour or 1200 ECU's per day (forfait). In a medium length project of 60 days, 20 of them are dedicated to the mix for surround/spatialisation. A tool like I'M EASY could reduce these costs for about 8.000 ECUs,

- to obtain an acceptable spatialisation on multi-channel systems or a surround project codified on a stereo master, it is nowadays necessary to operate on audio materials through several steps, from the original record until the final master. By taking advantage of I'M EASY technology, not all the steps will be eliminated, but the same sound engineer that takes care of editing and mixing music could save up to 20% of the time spent programming his console or every single channel movement on software systems, with a cost of 120 ECUs per hour, when a serious audio project takes not less than one week for the mixing (8 to 10 hours per day),

- a multimedia project takes not less than 1 month to finish the audio project and a soundtrack for movies takes up to 6 months. By considering that every single scene needs different positioning and movements for the music and sound effects (all of those on multi-channel basis), I'M EASY can make the sound designer saving up to 30% of the production time.

I'M EASY approach

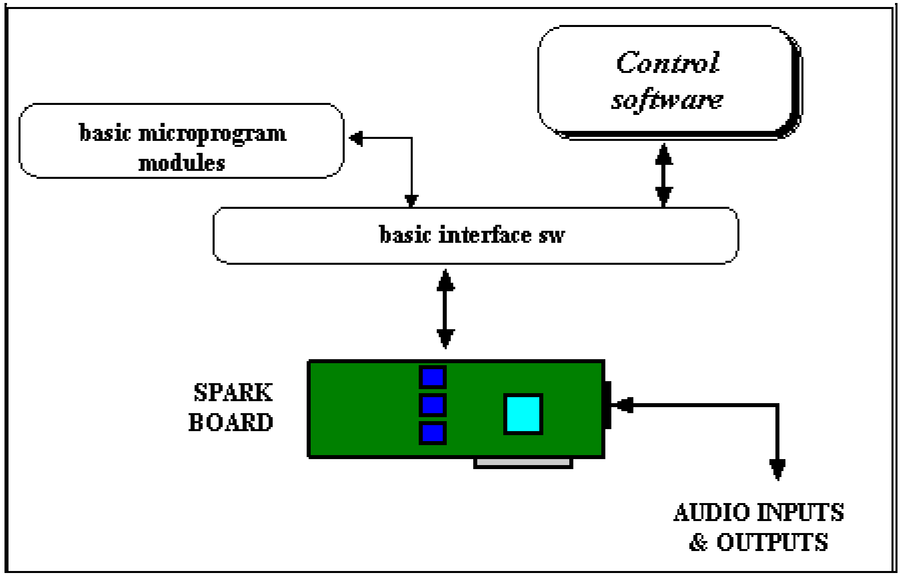
I'M EASY activity plans to exploit the higher computation power, larger on-chip memory, ease of use and generality qualities of the SHARC DSP devices, based on the adoption of SPARK architecture of IRIS.

The adoption of SPARK mainly consists in testing the spatialization algorithms and their validity in a musical context. This will be an efficient support to reduce the effort for implementing a prototype, as well as the interconnection and digital mixing in hardware, and to focus this project on HPCN technology transfer.

A big effort has been made to map as nearly as possible the functionality of the low level libraries for the host computer, which manages all the I'M EASY board resources, to the functionality of the SPARK system. This approach has been chosen in order to maintain the same software architecture successfully tested on SPARK, and to allow testing part of the high level of software on SPARK while waiting for the new board to be developed.
Using HPCN technologies, the complete system will reach a greater value with respect to SPARK, since a new and strongly innovative product with a set of new functionality and higher performance will be implemented.

For these reasons:

- the DSP board will be redesigned starting from the existing SPARK board but with some important additional features: multiple board interconnection, DRAM support, digital mixing section in FPGA, Audio Unit interface.
- the Audio Unit will be independent of the life of the product. The product could be distributed separately even to customers that already own such a unit.
- the Microprogram module set has been partially developed in a preliminary form for the SPARK prototype and has to be redesigned according to the high level specifications.
- the Low-level interface libraries will have to be developed and tested with special care as they are crucial to the correct interaction between hardware and software.
- the Control software will be developed to allow advanced configuration editing, saving and restoring, taking into account the need to dynamically reconfigure the available hardware and firmware resources. The current control software developed for the SPARK board is mainly dedicated to the testing of the simpler functionality and has to be redesigned to handle a reconfigurable environment.



SPARK system: overall architecture

State of the Art

Currently, even if there is a great interest in multichannel audio systems, it is mainly focused on coding/decoding techniques and reproduction sound systems, which are especially important in the cinema and home theater industry.

- Market Situation
- Current Operational Way

The proposed system intends to fill a gap in the current commercial market, as it will provide a device for creating in real-time original spatialization effects that can then be encoded as needed and reproduced on either custom or already installed sound systems.

With I'M EASY activity, the partners have exploited a strongly innovative idea: automating and managing, in real time, the position and the movements in the audio space of one or more audio sources during mixing process and public performance of concerts, as well as for theatre or disco-dance based events.

With respect to other spazialization systems available on the market and to the old architecture of A&G (Sigma 1 plus ProTools), I'M EASY with comparable performance at a lower cost, will increase the number of systems commercialised by A&G with a return of investment, at least of about 45% in three years. The expected cost/price reduction should reach an economy of 40-50 systems compared to other commercial spatialization equipments (not offering the same features of I'M EASY) for a turnkey solution.

I'M EASY general architecture

I'M EASY is a hardware/software solution. The main tasks of 'M EASY are automating and managing, in real time, the position and the movements in the audio space of one or more audio sources during mixing process and public performance.

As the amount of computing power may not be sufficient for applications with many outputs to handle, I'M EASY system will support a multiple-board configuration, where algorithms can be easily partitioned into independent functional blocks. I'M EASY architecture represents a good example of the usage of the HPCN technologies.

Architecture Overview
Involves both hardware and software aspects.

The software architecture description of I'M EASY can be decomposed in three different levels:

- DSP level

  Contains the DSP microprograms.
- Control level

  A set of low level libraries for the host computer, which manages all the EZ-SOUND board resources.
- High Level Control Application (HLCA)

  An interface application program, containing the user interface and the capability to interact with lower software level.

The hardware component of I'M EASY is:

- EZ-SOUND

  A PCI board for PC-compatible computers, to be used in a multi-board assembly by I'M EASY system.

I'M EASY reports

- Information Document First Semester

I'M EASY related sites

Organizations

- ASE Audio Engineering Society
- SMPTE Society of Motion Picture and Television Engineers
- APRS Association of Professional Recording Services
- ESTA Entertainment Services & Technology Association
- SPARS Society of Professional Audio Recording Services
- IRMA The International Recording Media Association
- ICMA International Computer Music Association
- NAMM International Music Product Association
- Swedish Studio Engineers Society
- IBS Institute of Broadcast Sound (UK)
- AIMI Associazione di Infomatica Musicale Italiana
- EMF Electronic Music Foundation
- MMA Midi Manufacturers Association
- Italian MIDI
- ATSC Advanced Television Systems Committee
- EBU European Broadcasting Union
- INA Institut National de l'Audiovisuel
- IRCAM Institut de Recherche et Coordination Acoustique / Musique
- ABTT Association of British Theatre Technicians
- ASA Acoustical Society of america
- USITT United States Institute for Theatre Technology
- OISTAT International Association for Scenographers, Theatre Archtitects & Technicians
- Scotts Theatre Links
- BEAST Birmingham ElectroAcoustic Sound Theatre
- IASIG Interactive Audio Special Interest Group
- ACM SIGSOUND Special Interest Group on Sound software and hardware
- AMPAS Association of Motion Picture Arts & Sciences

Spatialization

- Ultimate Spatial Audio Index
- Audio and Three Dimenisional Sound Links
- Euphonia
- Spatial Sound Links

Recording Studios

- Ocean Way Recording
- Logic Recording Studio
- Mulinetti recording studio
- Studio Sintesi
- Capri Digital Studio
- Cat Sound Studio
- Music Lab
- ph Music Work

Journals & Magazines

- Studio Sound
- AudioReview
- Strumenti Musicali
- Audiomedia
- Keyboards
- Studio Post Pro
- Keys
- Computer Music Journal
- Applied Acoustics
- IEEE Transactions on Speech and Audio Processing
- Electronic Musician
- Mix Magazine
- EQ Magazine
- Music & Computers
- Leonardo Music Journal
- Lighting & Sound International - The Entertainment Technology Monthly
- Sound+Communication Systems International
- ACM SIG-SOUND Gopher
- JAC Page at USF
- ACM Special Interest Group on Sound and Computation

Conferences

- International Computer Music Conference
- ICAD International Conference on Auditory Display

Music Files

- Harmony Central Internet Music Resource List
- The "Ever-expanding" Web Music Listing
- The Web Wide World of Music
- A History of Electronic Instruments
- Computer Music Software List
- Archives of Classical MIDI Sequences
- Demonstrations of Renaissance Instruments
- The Binaural Source
- Cyborgasm
- Interactive Sound Installation
- Virtual Audio Sampler

Products

- Apogee Electronics
- Digidesign
- MusicPro - for the music and recording industry
- The Ambisonic
- Dolby Laboratories Inc.
- DTS Digital Theatre Systems
- Opcode
- Origin Records
- Digital Audio Labs
- D.A.W. Mac
- Arboretum Systems
- 3D Sound
- Aureal
- CATT-Acoustic
- Crystal River Engineering
- Firsthand
- Headspace
- Holophonics
- Intel Corp.
- Lake DSP
- Level Control Systems
- NuReality
- Paradigm Simulations Inc.

- QSound
- Reality by Design
- Roland Corporation
- Sony
- Spatializer Audio Laboratories
- Hardware/Software

HPCN: High Performance Computing and Networking

- Dr. Ing. Paolo Nesi
- DSI, Dipartimento di Sistemi e Informatica
- Universita' degli Studi di Firenze
- nesi@dsi.ing.unifi.it
- http://www.dsi.unifi.it/~nesi

Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Support

- CESVIT as TETRApc partner
- DSI as executive partner of CESVIT for HPCN
- Support for the definition of proposals
- Support as Research Center on HPCN

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Perche' ?

- Possibilita' di Finanziamento 50%
- Realizzazione di Proposte
- Nostro Supporto come Centro di Competenza HPCN

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Possibilita’ di Finanziamento

- Grande richiesta di progetti HPCN
- finaziamento 50% o 100% costi marginali
- SME: dip. or MECU
- Realizzazione di full project HPCN
- Realizzazione di progetti
- con il supporto di un TTN

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

HPCN Technology

- Distributed Systems
- Parallel Architectures
- High Performance Workstations
- Clusters of Machines
- Etherogeneus Architectures
- Internet and Intranet
- Real Time Systems
- .....

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

HPCN: Application Fields

- Factory Integration, CIM
- Systems of Control: HW-SW
- Embedded Systems: HW-SW
- Wide/Local Area Network: HW-SW
- Image Processing, Comp. Vision: HW-SW
- High Performance Networks: HW-SW
- Electro-Medicals: HW-SW
- Electro-Musicals: HW-SW
- ....

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Integration In Manufacturing, CIM

- Integration CAD/CAM and machines areas
- Parallelisation of Algorithms
- Multi-microP, Embedded
  - Remoting and improving CAD/CAM
  - Defect Detection
  - Control of production
  - Simulation
  - ....

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Medicale

- Distrib. di Applicazioni/Servizi, WAN
- Parallelizzazione di algoritmi
- Elaborazione di immagini
- Ricostruzione e manipolazione solidi
- Simulazione comportamento protesi
- Simulazione comport. tessuti umani
- Supporto in Sala Operatoria
- ....

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Multimedia

- Parallelizz. di algoritmi di conversione
- Distribuzione, virtualizzazione di servizi
- Editor/servizi cooperativi/distribuiti
- Virtualizzazione di basi di dati
- Sistemi di conversione
- Simulazione 2D, 3D, 4D
- Virtual Reality
- ....

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Sensoristica

- **Sistemi Embedded e Multiproc**
- **Parallelizzazione Algoritmi**
- **Detection di difetti**
- **Monitoraggio per controllo ambientale**
- **Misure in Tempo Reale su pazienti**
- **Interfacce Utente/Supporti per Disabili**
- **.......**

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Embedded Systems, HW-SW

- Multi-processor architecture
- Concurrent Systems
- Reliable Distributed Systems
- Real Time Systems
  - Optimisation of Algorithms,
  - Scheduling Task
  - Performance Improvement
  - ....

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Computer Vision and Image Processing

- Motion Analysis: measures, recognition
- Counting moving objects
- Detection of Cavity Conditions
- Defect Detection
- Measures, Control of Flows: turbine, water, etc.
- ASIC, VLSI, PGA
- Special Purpose Architectures
- ……….

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Objectives of HPCN Domain

Facilitare l'adozione di tecnologie HPCN per

- **incrementare prestazioni**
- **migliori e nuove funzionalita'**
- **distribuire servizi**
- **disseminare tali tecnologie**
- **dimostrare le potenzialita' delle tecnologie**

Diapositiva precedente   Diapositiva successiva   Torna alla prima diaposiva   Visualizza versione grafica

Diapositiva di PowerPoint

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

HPCN: Progetti

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

HPCN: Progetti

- **per es.: da mono a multiprocessore**
- **per es.: da standalone a distribuito**
- **Parallelizzare**
- **distribuire**

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

HPCN: Progetti

- **chiari benefici per l'end-user e per l'industria**
- **motivazioni: quantitative e qualitative**
- **disseminazione nazionale e internazionale**
- **controllo quantitativo del progetto**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Progetti Supportati dal TTN

- **Presentazione di progetti in continuo**
- **Progetti preparatori**
- **Progetti di diffusione della tecnologia**
- **Progetti di trasferimento tecnologico**
- **Progetti di rivalutazione**
- **Consorzio non internazionale**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Tipologie di Progetti

- **task 6.21: Studi di Fattibilita’**
- **task 6.22: Promozione di Tecnologie HPCN**
- **task 6.23: Dimostrativi**
- **task 6.24: Best Practice**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Preparatory & First User Action

- **Valutare i vantaggi dell'HPCN**
- **Diffondere l'HPCN**
- **Facilitare l'uso di tecnologie HPCN**
- **Rendere i prodotti piu' competitivi**
- **....**

Pisa Ricerche

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Studi di Fattibilita' (task 6.21)

- **Industria e Centro(i) di competenza**
- **End-User (anche meglio)**
- **Industria come First User**

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Studi di Fattibilita' (task 6.21)

- **HPCN per migliorare prodotti tradizionali**
- **Realizzazione di un Prototipo ``grezzo''**

Prodotto

HPCN

PrePrototipo

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Promozione di Tec. HPCN (task6.22)

- **es: Industria e Centro(i) di competenza**
- **es: Assoc. di Categoria e Centro di competenza**
- **Diffusione di Tecnologie HPCN**
- **Valutazione dei ritorni**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Dimostrativi (task 6.23)

- **Industria + Centro(i) di competenza**
- **Uno o piu' End-User**
- **Validazione**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Dimostrativi (task 6.23)

- **Presenza di uno studio di fattibilita’ (prototipo)**
- **Porting/adaption, optimization, test/validation**
- **HPCN per migliorare/``realizzare’’ prodotti**
- **Realizzazione di un Prototipo esteso**

prototipo

tecnologia

NUOVE

FUNZIONALITA’

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Best Practice (task 6.24)

- **Industria e Centro(i) di competenza, o**
- **SME + grossa industria (technology provider)**
- **Uno of piu’ ``End-User’’**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Best Practice (task 6.24)

- **Presenza di un prodotto HPCN**
- **HPCN per migrare/re-ingegnerizzare prodotti**
- **istallation**
- **testing**
- **validation**
- **maintenance**
- **training**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Dimensioni dei Progetti

- **Task 6.21**
- **Durata: 6 mesi, Lavoro: 6 mesi/uomo**
- **Task 6.22**
- **Durata: 12 mesi, Lavoro: 6+6 mesi/uomo**
- **Task 6.23 e 6.24**
- **Durata: 18 mesi, Lavoro: 4 anni/uomo**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Il Consorzio

- **Anche solo composto da Italiani**
- **Industria(e) + Centro(i) + [End-User(s)]**
- **Industria(e) + Tech.Provider(s) +[end-user(s)]**
- **Bilanciato**
- **Motivato**
- **Competente**
- **Affidabile**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Stesura della Proposta

- **Dimensioni contenute (max 30 pag.)**
- **Parte Finanziaria**
- **Parte Tecnica**
- **Allegati Tecnici**
- **Allegati Promozionali**

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La Parte Finanziaria

- **Consuntivo Economico**
- **Form da compilare**
- **Lettere di Adesione al Consorzio**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

La Parte Tecnica

- **Why: Perche’ ve ne e’ necessita’?**
- **What: Cosa verra’ proddotto?**
- **Who: Chi eseguira’ il lavoro?**
- **How: Come verra’ eseguito?**

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Why: Perche’ ve ne e’ necessita’?

- **Stato del mercato**
- **Necessita’ ed Opportunita’**
- **Stato dell’Arte tecnico**
- **Problemi rilevanti**
- **why to buy?**
- **why to change?**

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Benefici per l’End-User

- **nuove funzionalita’**
- **nuove prestazioni**
- **costi vantaggiosi rispetto al mercato**
- **risparmio: riduzione tempi di esecuzione**
- **risparmio: riduzione tempi di attesa**
- **disseminazione e incremento di immagine**
- **......**

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Disseminazione Risultati

- **Nazionale e a livello Europeo**
- **Partecipazione a fiere**
- **Partecipazione a congressi**
- **Pubblicazione di articoli**
- **Organizzazione di Dimostrazioni Pubbliche**

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Our Support

- Identification of Proposal Area
- Identification of Proposal Task
- Support for:
  - Partners Collection
  - Definition of the Team
  - Implementation of the Proposal

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

References

Ing. Paolo Nesi

DSI, Dip. di Sistemi e Inform.

Facolta’ di Ingegneria

Via S. Marta, 3

50139 Firenze

Tel: 055-4796523

Fax: 055-4796363

email: nesi@dsi.ing.unifi.it

http://aguirre.dsi.unifi.it/~hpcn

Ing. Maurizio Campanai

CESVIT (High Tech Agency)

Fortezza da Basso

Via Pian dei Carpini, 28

50127 Firenze

Tel: 055-42941

Fax: 055-4294220

email: campanai@cesvit.it

http://www.cesvit.it/

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Approved Proposals

- MOODS
- ICCOC
- MUPAAC
- ASPECT
- MASC

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Project MOODSMusic Object Oriented Distributed System

TTN - TETRApc

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Diapositiva di PowerPoint

- Reduction of time for modifications
- Reduction of time in rehearsals
- Saving of interpretation/instrumental information
- Automatic, centralised Turning of Page
- Demonstration & Dissemination
- Network 100VG, embedded, LINUX,......
- ...…advanced prototype.

Project MOODSMusic Object Oriented Distributed System

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Diapositiva di PowerPoint

- Task 6.23
- Cooperative Editor of Scores
- Substitution of paper in orchestras
- Integration with the archive of scores
  - from Stand-Alone to Distributed
  - New application field
  - New products
  - New market

Project MOODSMusic Object Oriented Distributed System

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Diapositiva di PowerPoint

- DSI, Dip. Sist. e Inf., Univ. FI (tech.prov), PC
- Teatro Alla Scala (end-user), Theatre
- BMG Ricordi (end-user), Publisher
- Scuola di Musica di Fiesole (end-user),
- ELSEL (tech.consumer), Industrial Firm
- Shylock (tech.provider), Distributed Databases of Music

  Project MOODSMusic Object Oriented Distributed System

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Diapositiva di PowerPoint

- Project Coordinator: DSI (Paolo Nesi)
- Task: 6.23 (demonstration)
- Start: 15 July 1997
- Duration: about 1 year
- Total Costs: 497809 ECUs
- Total Funding: 248904 ECUs (50%)
- Man/year: 3.87

Project MOODSMusic Object Oriented Distributed System

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Diapositiva di PowerPoint

Project MOODSMusic Object Oriented Distributed System

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Project ICCOCIntegrating CAD/CAM Operations into CNC-Based Machines

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Diapositiva di PowerPoint

- Reduction of times for changes in CAM
- Reduction of times for validating pieces
- Optimisation of production costs
- Integration of the factory
- Network Monitoring
- Demonstration & Dissemination
- Network, Windows NT......
- ……early prototype

Project ICCOCIntegrating CAD/CAM Operations into CNC-Based Machines

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Diapositiva di PowerPoint

Project ICCOCIntegrating CAD/CAM Operations into CNC-Based Machines

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Diapositiva di PowerPoint

Definition of Main Requirements

- Remoting CAD/CAM on CNC for modifications in real-time
- Executing CAM on the based of CNC details (geometry, tools, etc.)
- Generating/Modify Measure Sections on CNC
- Supervising Milling Machines Area (MM + Robots)
- Optimizing resources of both CAD/CAM and CNC areas, network management (Computer, machines, pieces, etc.)
- Fast access to data from CNC into CAD and CAM databases
- ....
-

Project ICCOCIntegrating CAD/CAM Operations into CNC-Based Machines

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Diapositiva di PowerPoint

- Task 6.21
- Remote execution of CAD/CAM on MT
- Dynamic Optimisation of Resources
- Reliable data transfer
  - from Stand-Alone to Distributed
  - New functionalities
  - New Product
  - Increment of Market

Project ICCOCIntegrating CAD/CAM Operations into CNC-Based Machines

Diapositiva precedente   Diapositiva successiva   Torna alla prima diaposiva   Visualizza versione grafica

Diapositiva di PowerPoint

- ELEXA (Project Coordinator)
  - (tech.consumer), supplier of CNC
- DSI, Dip. Sist. e Inf., Univ. FI (tech.prov)
- TECMA (end-user), Production of Templates

Project ICCOCIntegrating CAD/CAM Operations into CNC-Based Machines

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Diapositiva di PowerPoint

- Project Coord.: ELEXA (Marco Perfetti)
- Task: 6.21 (early study)
- Start: 15 July 1997
- Duration: 6 months
- Total Costs: 58310 ECUs
- Total Funding: 29155 ECUs (50%)
- Man/year: 0.631

Project ICCOCIntegrating CAD/CAM Operations into CNC-Based Machines

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

Project MUPAACMulti Processor Architecture For Automatic Control

Diapositiva di PowerPoint

- Cost/Price Reduction for Control Systems
- Scalability of Control Systems
- Open Arch. for Factory Integration
- Demonstration and Dissemination
- Integrated System for Producing passpartout
- PCI, CANbus, ...
- ......prototype

Project MUPAACMulti Processor Architecture For Automatic Control

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Diapositiva di PowerPoint

- DEMONSTRATION, 6.23
- From Dual-Processor to Multi-Processor
- Configuration Flexibility
- System Integrability
- From Low to Med-performance
  - New functionalities
  - Increment of the market

Project MUPAACMulti Processor Architecture For Automatic Control

Diapositiva precedente | Diapositiva successiva | Torna alla prima diaposiva | Visualizza versione grafica

Diapositiva di PowerPoint

- SED (PC) (Tech.consumer), CNC builder
- DSI, Dip. Sist. e Inf., Univ. FI (tech.prov), HPCN architecture and HW-SW
- VALIANI (end-user), Passpartout Builder
- CESVIT (tech. prov.)
- DIE, Dip. Ing. Elettronica (tech.prov.), ASIC

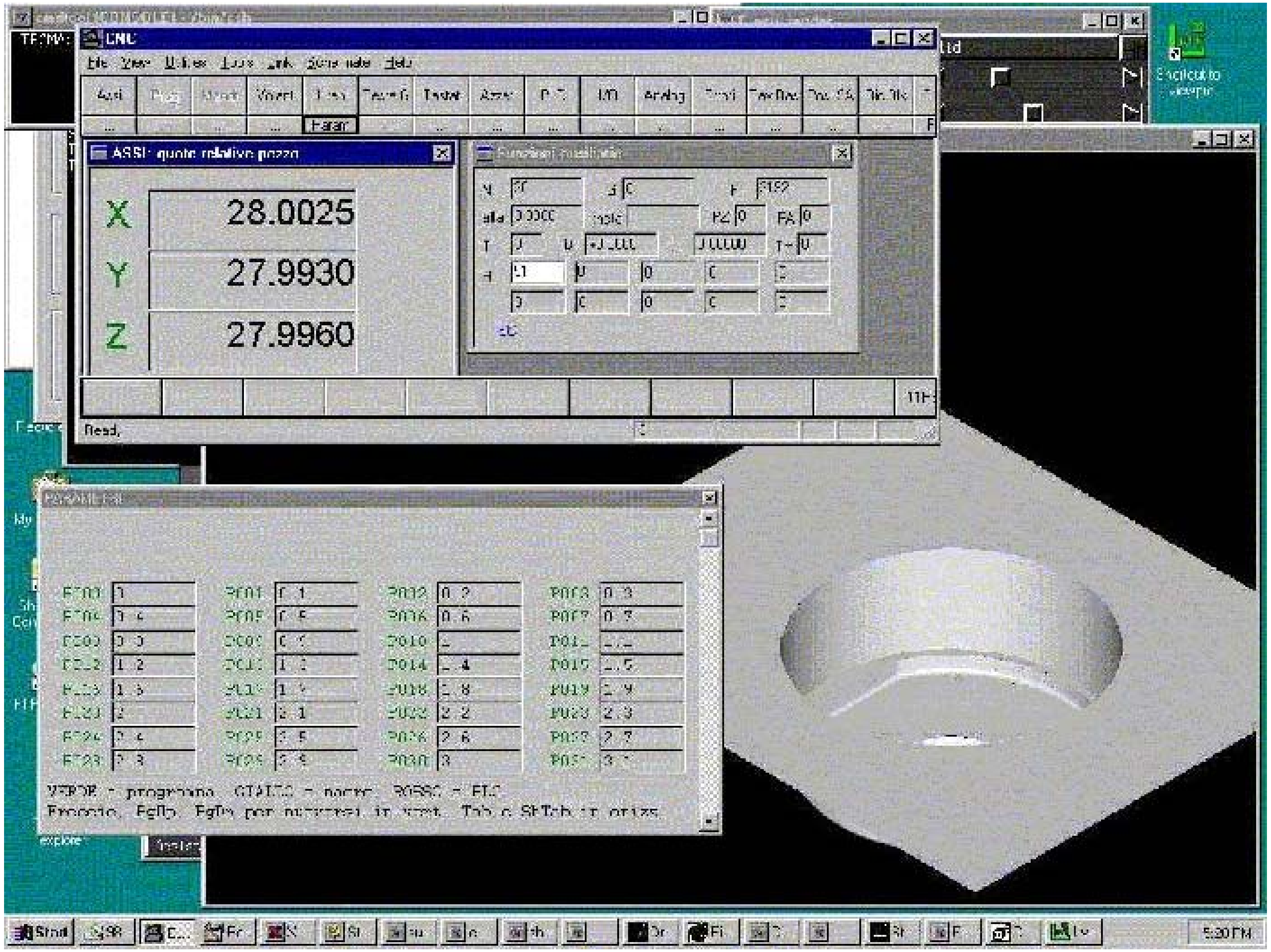
  Project MUPAACMulti Processor Architecture For Automatic Control

Diapositiva precedente Diapositiva successiva Torna alla prima diaposiva Visualizza versione grafica

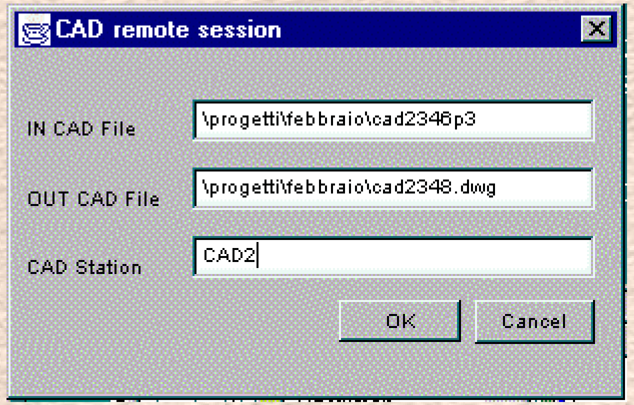
Diapositiva di PowerPoint

- Project Coordinator: SED (Carlo Bruni)
- Task: 6.23 (demonstration)
- Start: to be received
- Duration: 1 year
- Total Costs: 428750 ECUs
- Total Funding: 214375 ECUs (50%)
- Man/ years: 3.86

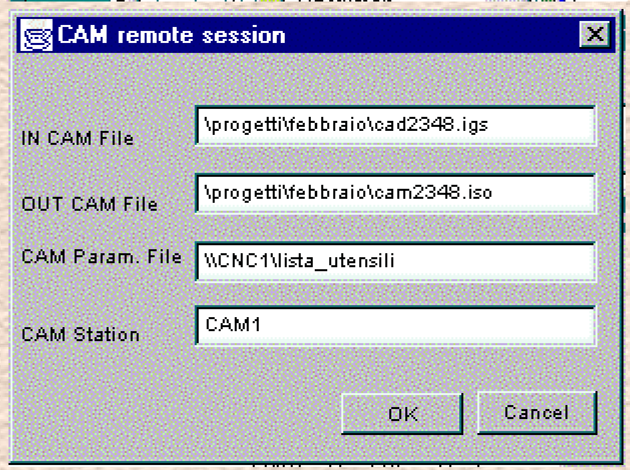
Project MUPAACMulti Processor Architecture For Automatic Control



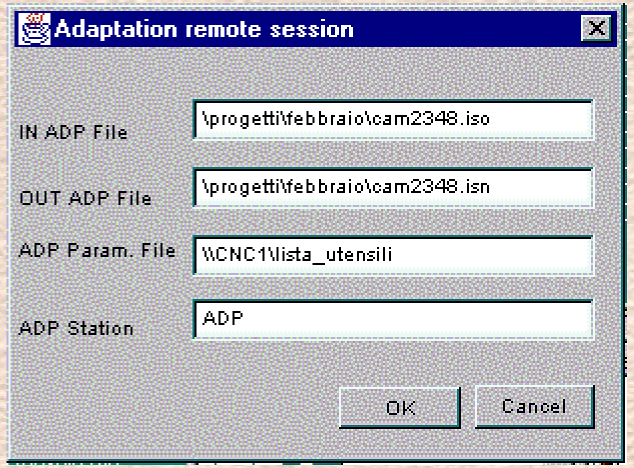
CNC
ASSI: quote relative pezzo
X 28.0025
Y 27.9930
Z 27.9960



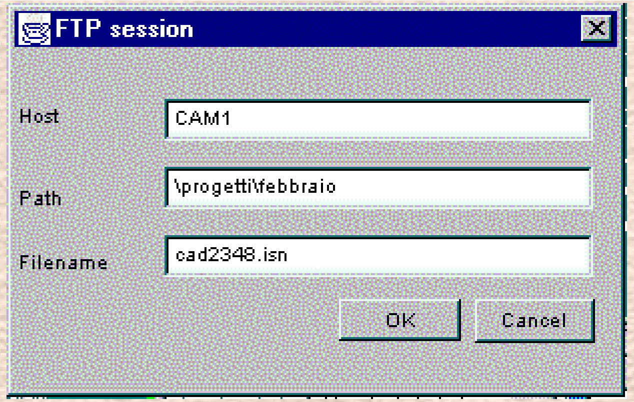
The CAD button allows you to select the CAD station that has to run the remote session, the input and output file.



The CAM button allows you to select the CAM station that has to run the rennet session, the input and output file and the parameter file for CAM generation.



The ADP button allows you to select the Adaptation station station that has to run the rennet session, the input and output file and finally the configuration file that contains all the information about tools that are present on the CNC station.



The FTP button allows you to transfer automatically the needed file to the CNC station in order to start the work without going around with a tape or a magnetic support.

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

FACTORY INTEGRATION: CAD/CAM ON MACHINE TOOLS

ELEXA & TECMA

ICCOC project has demonstrated the possibility of integration of CAD/CAM functionality on CNC-based machines by means of HPCN technology. The integration of CAD/CAM allows the reduction of costs related to non-planned CAD/CAM activities of at least 35 %. Milling Machines, for making templates are typically used for producing unique and special templates. These usually need several CAD/CAM remakes on the basis of the machine adopted, on the machine configuration, and on the shape of the coarse piece from which the template is obtained. These facts and the lack of integration between CAD/CAM and MMs areas cause large problems of delay. The main result has been to pose the basis of implementing a new category of products for integrating CAD/CAM and MMs areas obtaining an optimal exploitation of resources. This has allowed the opening and the conquer of a new market, and as well as the consolidation of the present market.

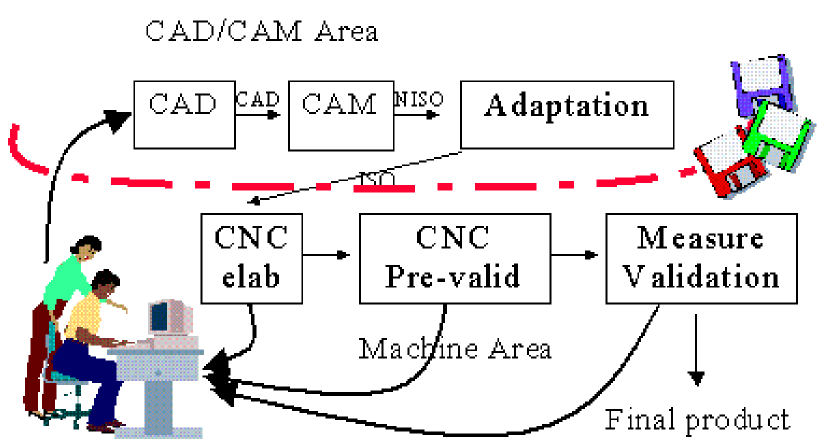
This activity was carried out under the TETRApc TTN. TETRApc can be contacted by email (nesi@dsi.unifi.it, nesi@ingfi1.ing.unifi.it) or by telephone (+39-055-4796523) or FAX (+39-055-4796363). The initial contact is Paolo Nesi.

--detailed version--

ELEXA is builder of CNCs for milling machines and robots of CB Ferrari (one of the most important European Milling Machine builder). TECMA is a factory for template production.

Typically, a center of production (an island of production) is comprised of several milling machines, one or more robots, a measuring machine. The islands are only slightly connected with CAD/CAM area. The typical Milling Machines produced are mainly used for producing small series of templates. This type of production is very specific since templates have to be considered unique pieces for which the precision and the finiteness degree are really critical. The process of refinement includes phases in which CAD, CAM and milling are iterated.

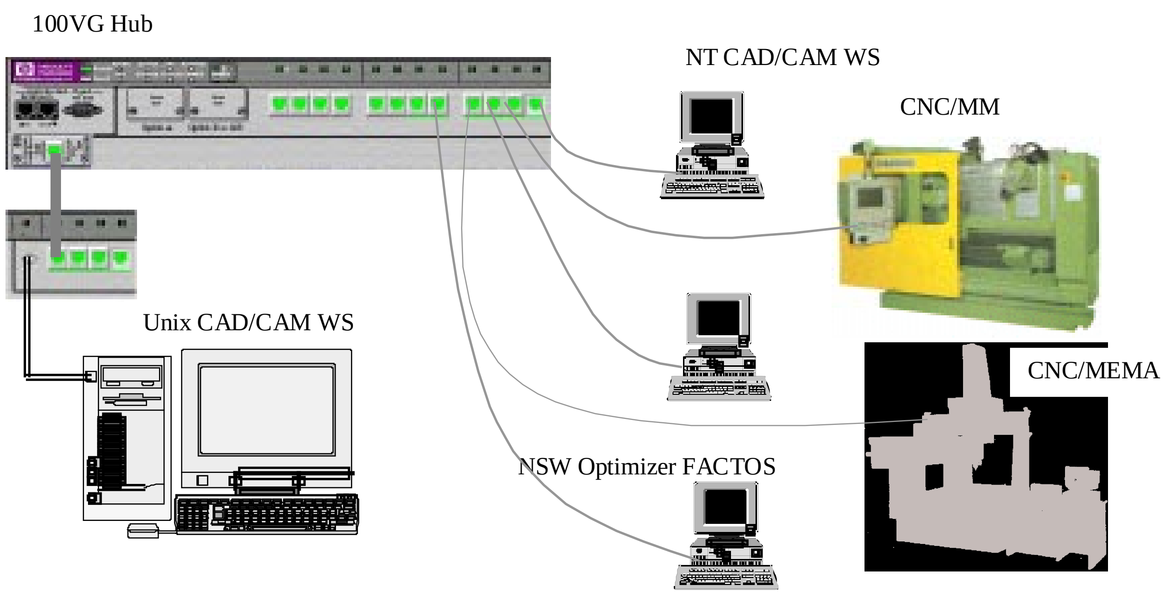
Presently, communications and relationships between CAD/CAM and the CNC area are mainly carried out by using humans carrying foils and messages. In the most competitive solutions file transfer is used; but it doesn't solve the problems of integration. Changes on CAD, CAM files have to be made on CAD/CAM area and the two areas are physically located very far to each other. This fact leads to have high costs for making corrections on CAD/CAM phases in the production process. ICCOC: Integration of CAD/CAM Operations into a CNC-based (Computerized Numerical Control) Machine.



THE SOLUTION

The ICCOC project consists of a feasibility study to assess the possibility of the integration of CAD/CAM functionality on CNC-based machines using HPCN technology. The main idea is to adopt a fast, reliable, noise-robust network to execute CAD/CAM applications on remote CNC machines and to optimize exploitation of the resources present in CAD/CAM and Milling Machine areas.

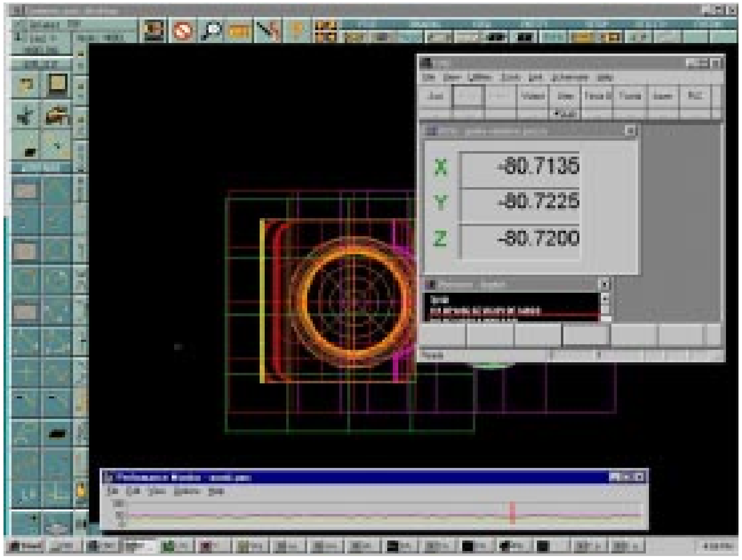
The result of ICCOC feasibility study is the profile of the main aspects of a new product for optimizing processes of production and integrating the factory resources: reduction of time for changes in CAD/CAM phases, reduction of time for validating pieces, optimization of production costs, and improvement of factory integration and quality management.



These goals can be achieved by using the support of these four main components:

- Remote execution of CAD/CAM/Adaptation workstations on CNC and measuring machines;
- File transfer from the machine containing the file(s) and that which has to used it;
- Monitoring and Measuring in real-time the activity of the factory and that of its components;
- Planning and Re-Planning in real-time the activities of CAD, CAM, Adaptation workstations, CNC and measuring machines;

The execution of CAD/CAM applications on MM consoles must be supported by mechanisms for dynamic optimization of CAD, CAM and MMs resources.
The same network could be used for delivering commands that are typical of CIM policy (monitoring and planning activities carried out by machines). By using a such network support and general services the CIM policy can be expanded to plan also the CAD/CAM/adaptation activities.
The above mentioned requirements seem to be contradictory since the transferring of working programs in short time (from the CAM and adaptation stations to CNC) needs a high throughput, while the sending of commands in real-time (synchronization commands, alarms, etc.) means high reliability and predictability.
It is in our opinion that these problems can be solved by adopting a fast and reliable supports based on a priority-based protocol such as 100VG, ATM, etc. Even Fast Ethernet (100 BT) if it is carefully used. These are typically problems solvable with HPCN technology. Other networks or control networks are less predictable or too slow (CAN, Token Ring, Lonworks, WorldFIP, PROFIBUS, etc.).



In the tests about the Possibility of Measuring, Planning and Re-Planning, we adopted different workloads on the network simulated by:

- Activation of the remote execution of the CAD;
- Activation of the remote execution of the CAM;
- Activation of the remote execution of an FTP;
- Testing of the client-server architecture of the prototype when several clients are open and operate on the same data;
- Testing of the client-server architecture of the prototype when several clients are open and operate on different data.

By the report of the result we found that:

- The load of the Prototype on the network can be neglected with respect to the other loads
- Remoting is feasible and cheap
- Is also well-considered by End-Users
- Network support chosen is adequate

Real economical benefits have been detected by end-users

THE EXPERIENCE OF TECMA

To this end HPCN technology has been used and can be profitably used for distributing the information and services along the factory. Specifically for the production process optimization: for monitoring the factory activity and optimizing resources according to simple schedule mechanisms and considering the status of a database containing specific information the best solution seems to be the Intranet Technology.

ELEXA has been supported in introducing HPCN technology into its products by DSI, Department of Systems and Informatics, of University of Florence. The prototype produced has been tested and validated by TECMA a producer of templates.

The registered industrial benefits:

- Reduction of costs for the remake of a CAD and/or a CAM phase of 60%
- Reduction of time for remake of a CAD and/or CAM phase of 20%
- Optimization of production process: saving 20%
- Re-qualification of people working on CNC

Thus a New Product and a New Market will be identified and shown. A small phase of dissemination has been drawn among factories involved in the first phase of requirement analysis of the feasibility study. From this, as a first result, some concrete agreements for implementing integrated islands of production including ICCOC capabilities has been received.

FURTHER DETAILS:

http://www.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

For further information contact:
Adolfo Villoresi, Marco Perfetti,
ELEXA, TECMA
Via delle Panche 38A, Firenze 50100, Italy
tel: +39-055-435119, fax: +39-055-4376334
email: elexa@tin.it

This activity was carried out under the TETRApc TTN. TETRApc can be contacted by email (nesi@dsi.unifi.it, nesi@ingfi1.ing.unifi.it) or by telephone (+39-055-4796523) or FAX (+39-055-4796363). The initial contact is Paolo Nesi.

Public Final Report of ESPRIT HPCN PST Activity:

ICCOC - Integrated CAD/CAM Operations into CNC-based machines

ELEXA

DSI, University of Florence

TECMA

Ver.1.0, 31/8/98

1. ABSTRACT

ICCOC project consist in a preliminary study for assessing the possibility of integration of CAD/CAM functionality on CNC-based machines by means of HPCN technology.

ELEXA (Project Manager and Technical consumer) builds CNCs (Computerized Numerical Controls) for milling machines, MMs, for making templates. These particular kind of machines are strongly re-configurable and are used for producing unique and special templates. These usually need several CAD/CAM remakes on the basis of the machine adopted, on the machine configuration and on the shape of the coarse piece from witch the template is obtained.

The objective of this project has been the identification of a suitable network to support the integration between the CAD/CAM area and the machine area so to allow a reliable and fast remote execution of CAD/CAM applications on MMs console concurrently to the machine control, the dynamic optimization of CAD, CAM and MMs resources, fast and reliable transferring of very large quantity of data.

2. SYNOPSIS

The objective of this project has been the identification of a suitable network to support the integration between the CAD/CAM area and the machine area so to allow a reliable and fast remote execution of CAD/CAM applications on MMs console concurrently to the machine control, the dynamic optimization of CAD, CAM and MMs resources, fast and reliable transferring of very large quantity of data.

ELEXA (the technical consumer of this project) builds Computerized Numerical Controls for Milling Machines, MMs, for making templates in unique pieces with very high precision of finishing on the machine. Templates are typically defined on CAD/CAM stations but their design must be frequently customized changing shape, and CAM parameters. This need leads to a heavy exploitation of CAD/CAM stations for considering issues strictly related to MMs, these are in turn very far from the CAD/CAM user mind-set. MMs for templates have to change, as fast as possible, their working program for each piece. Moreover, the description of these templates in terms of working program is very heavy since they must be produced with a high precision and this lead to have very large working programs -- e.g., several tenths of megabytes. Precision, also means to have very specialized and costly MMs. The pieces are defined on CAD/CAM stations but their design must be frequently customized changing shape, and CAM parameters. This need leads to a heavy exploitation of CAD/CAM stations for small and MMs-related issues that are in many cases very far from the CAD/CAM user mind-set. For these reasons, some builders have decided to integrate on CNCs for MMs also operations partially performed on CAD/CAM stations. For example, the visualization of working program (both in graphics and statements forms) for obtaining a specific mechanical piece, the implementation of coarse working programs on the basis of simple graphic editors. In the enterprises, which base their economy on producing templates, it is necessary to reduce as much as possible the time during which the machine does not work -- i.e., from the working of a template to the next one -- the so called *dead time* of MM.

The improvement of the integration between the CAD/CAM area and the Machine Tools should encompass the hereinafter aspects:

- remote execution of CAD, CAM directly on the CNCs of the Milling Machines
- transferring of files among the several workstations of the factory should be implemented by using FTP or other higher level more reliable mechanisms
- monitoring the activity of the factory
- advertising (remote or local) the production manager
- planning and re-planning the activity in order to optimize the process of production.

To realize these services, a prototype has been implemented.

The benefits are:

> the reduction of costs for Re-CAD and Re-CAM operations, the reduction of time for Re-CAD and Re-CAM operations, optimization of production process, same user interface for programs and re-qualification of the operator of the CNC.

A slide summarising the results is included in Appendix A.

The ICCOC participants

ELEXA S.r.l. (prime contractor, HPCN technology consumer)
Via delle Panche, 38 A, I-50141, Firenze, Italy
Contact Person: Marco Perfetti
Phone: +39-55-43.51.19
Fax: +39-55-43.76.334
E-mail: elexa@tin.it

DSI (Department of System and Informatics) (HPCN Technology provider)
University of Florence, Via S.Marta, 3 A , I-50139 Firenze - ITALY
Contact person: Paolo Nesi
tel. +39 55 47.96.523
fax: +39 55 47.96.730
e-mail: nesi@dsi.unifi.it
WWW: http://www.dsi.unifi.it/~nesi

TECMA S.r.l. (End user)
Viale XX Settembre, 78
I-50019 Sesto Fiorentino, Firenze, ITALY
Contact person: Massimo Giorgetti
Phone: +39-55-44.42.41
Fax: +39-55-44.42.41

3. EXECUTIVE SUMMARY

The objective of this project is the identification of a suitable network to support the integration between the CAD/CAM area and the machine area so to allow a reliable and fast remote execution of CAD/CAM applications on MMs console concurrently to the machine control, the dynamic optimization of CAD, CAM and MMs resources, fast and reliable transferring of very large quantity of data.

ELEXA (the technical consumer of this project) builds Computerized Numerical Controls for Milling Machines, MMs, for making templates in unique pieces with very high precision of finishing on the machine. CNC is the main component of factory automation (Computerized Numerical Control), in which set of functionality can be automatically realized for the management of Machine Tools, MT. CNC-based machines, sequences of operative actions are defined by a set of instructions that are defined in the preparation phase for elaborating the selected piece of metal. Each mechanical part to be built on the machine is obtained by using a specific set of instructions (so called working program) containing all details: (i) operational actions and of (ii) machines outfit. In the working program, the sequence of operative actions is described according to a particular programming language, for example the well-known ISO (International Standard Organization). ISO programs are usually produced on a CAD/CAM (Computer Aided Design)/(Computer Aided Manufactory) workstation.

The presence of CNC for controlling MTs has also provided the support for implementing complex strategies and thus for building specific MTs such as Milling Machines, MMs, for templates. These are strongly complex and completely re-configurable machines mainly devoted to make unique pieces with high precision of finishing on the machine. MMs for templates have to change, as fast as possible, their working program for each piece. Moreover, the description of these templates in terms of working program is very heavy since they must be produced with a high precision and this lead to have very large working programs -- e.g., several tenths of megabytes. Precision, also means to have very specialized and costly MMs. The pieces are defined on CAD/CAM stations but their design must be frequently customized changing shape, and CAM parameters. This need leads to a heavy exploitation of CAD/CAM stations for small and MMs-related issues that are in many cases very far from the CAD/CAM user mind-set. For these reasons, some builders have decided to integrate on CNCs for MMs also operations partially performed on CAD/CAM stations; but their functionality are very far from those of a full CAD or CAM.

In the enterprises, which base their economy on producing templates, it is necessary to reduce as much as possible the time during which the machine does not work -- i.e., from the working of a template to the next one -- the so called *dead time* of MM. These enterprises usually adopt a workstation for the production of the template design on a CAD. The CAD design generation involves many man-hours and has as goal a mathematical description of the mechanical model. On the basis of the output produced by the CAD, the so called CAM module generates the working program (often under neutral form), for example neutral ISO (where some information are lacking and others need to be modified). This activity of modifying and fitting is implemented according to the MM technical information: (i) the size of tools, (ii) the machine structure (as number of axes, relationships among axes, moving modalities, etc.) and according to quality and final finishing up requirements of the part same. In particular, the commercial CAMs are capable to produce working programs in neutral form, on the basis of a CAD design and some technical information. These are independent from the kind of MM and from the shape of the rough part from which the template will be obtained. This makes the CAD/CAM outputs (Neutral ISO, NISO) totally independent on details of the MT and on the dimension of the coarse piece.

To resolve this gap, CNCs builders have the duty to fit the neutral program to the various controllers and to the various MMs through fitting up program (sometimes called post-processor or adaptation process). For this purpose the CAM output is provided with a set of adaptation programs, one for each type of MM which is present in the plant. So the CAM adaptation activity must be repeated for each MM, it is often necessary to repeat it for each part since the working program can change also according to the size and shape of the coarse piece of metal from which will be obtained the template. A different material removal involves a different tool path. It is also worth saying that the operator, who works at the CAD/CAM station, often does not know on which MM it will be implemented the template he/she is designing. MMs are usually very specific and hence each of these is substantially different from the other (at least as regards the same workshop) with respect to geometrical characteristics, tools, working velocity, etc. Such sizes are fundamental for obtaining the working program in the definitive form. Therefore, the MM selected influences the operations for customizing the ISO working program, to modify it according to technical characteristics of the MM and for considering the dimension of the coarse piece. In order to save dead time, the activity of adaptation should be specifically required by the CNC a short time before executing the working program in final form.

If the CNC is based on a computer with enough power, a possible way to work consists in executing the CAM and adaptation processed by the operator on the CNC itself. In this case the operator describes the actions to be performed by the MM starting from the paper version of the design produced by the CAD with the support of suitable tools. This method is pertaining to programs that are referring themselves to plane geometry parts that compose the solid. For example, the CNC user might need to carry out a working on a template in order to change a part of it. This kind of solution has been suggested in order to reduce the time needed for reporting the modifications directly on the CAD/CAM station by using CAD/CAM personnel. In fact, when a small modification is needed its execution on the CAD/CAM station is a very time consuming task for both CAD/CAM and CNC operators. This solution has been proposed by CNC builders as a technological evolution compared to the previous one (since it is possible only on machines having high performances CNCs). On the other hand, it involves greater costs for the machines, which have to provide the necessary power to control MM and to execute CAD/CAM activities in short time. This functionality could be considered as a further possibility to be used when the working programme generation is not conform with the requirements and it is necessary to re-execute both CAM and adaptation phases.

On the contrary, to make the modifications on the mechanical pieces directly on the MT leads to provoke a gap between CAD/CAM descriptions, documentation and the obtained template. The control process and thus the feedback needed for increasing quality is broken. Moreover, this type of solution has been also used for the lack of a true integration and quick communication between the machines tool department and that where CAD, CAM and adaptation phases are carried out.

It goes without saying that the improvement of the integration between the CAD/CAM area and the Machine Tools should encompass several aspects:

- remote execution of CAD, CAM and Adaptation Programs directly on the CNCs of the Milling Machines
- transferring of files among the several workstations of the factory should be implemented by using FTP or other higher level more reliable mechanisms
- monitoring the activity of the factory
- advertising (remote or local) the production manager
- planning and re-planning the activity in order to optimize the process of production.

To verify the aspect pointed out above, a mock-up prototype has been implemented.

The benefits are:

- the reduction of costs for Re-CAD and Re-CAM operations
- reduction of time for Re-CAD and Re-CAM operations
- optimization of production process
- same user interface for programs and re-qualification of the operator of the CNC

4. FULL TECHNICAL TEXT

4.1 State of the art

One of the main objective of this project has been the identification of a suitable network to support the integration between the CAD/CAM area and the machine area so to allow a reliable and fast remote execution of CAD/CAM applications on MMs console concurrently to the machine control, the dynamic optimization of CAD, CAM and MMs resources, fast and reliable transferring of very large quantity of data.

These particular kind of machines are strongly re-configurable and are used for producing unique and special templates. These usually need several CAD/CAM remakes on the basis of the machine adopted, on the machine configuration and on the shape of the coarse piece from witch the template will be obtained. Templates are typically defined on CAD/CAM stations but their design must be frequently customized changing shape, and CAM parameters. This need leads to a heavy exploitation of CAD/CAM stations for considering issues strictly related to MMs, these are in turn very far from the CAD/CAM user mind-set. MMs for templates have to change, as fast as possible, their working program for each piece. Moreover, the description of these templates in terms of working program is very heavy since they must be produced with a high precision and this lead to have very large working programs -- e.g., several tenths of megabytes. Precision, also means to have very specialized and costly MMs. The pieces are defined on CAD/CAM stations but their design must be frequently customized changing shape, and CAM parameters. This need leads to a heavy exploitation of CAD/CAM stations for small and MMs-related issues that are in many cases very far from the CAD/CAM user mind-set. For these reasons, some builders have decided to integrate on CNCs for MMs also operations partially performed on CAD/CAM stations. For example, the visualization of working program (both in graphics and statements forms) for obtaining a specific mechanical piece, the implementation of coarse working programs on the basis of simple graphic editors. In the enterprises, which base their economy on producing templates, it is necessary to reduce as much as possible the time during which the machine does not work -- i.e., from the working of a template to the next one -- the so called *dead time* of MM.

MTs are frequently related to each other by using robots and other mechanisms for the transport of mechanical pieces, these machines can be considered the glue among MTs. Robots and other mechanisms are usually managed by the same CNC which controls the MT/MM to which they are devoted. Connection among CNCs for implementing DNC policy on wider islands are typically made by means of dedicated I/O ports, one connection for each synchronization signal. The control is usually assigned to a CNC which controls the others by using a set of commands for distributing and synchronizing operational elaborations. Thus, it is usual to have DNC systems in which the central CNC is used for planning production according to CIM. While the other CNCs executed the specific operations.

4.1.1 State of the art: integration between CNCs

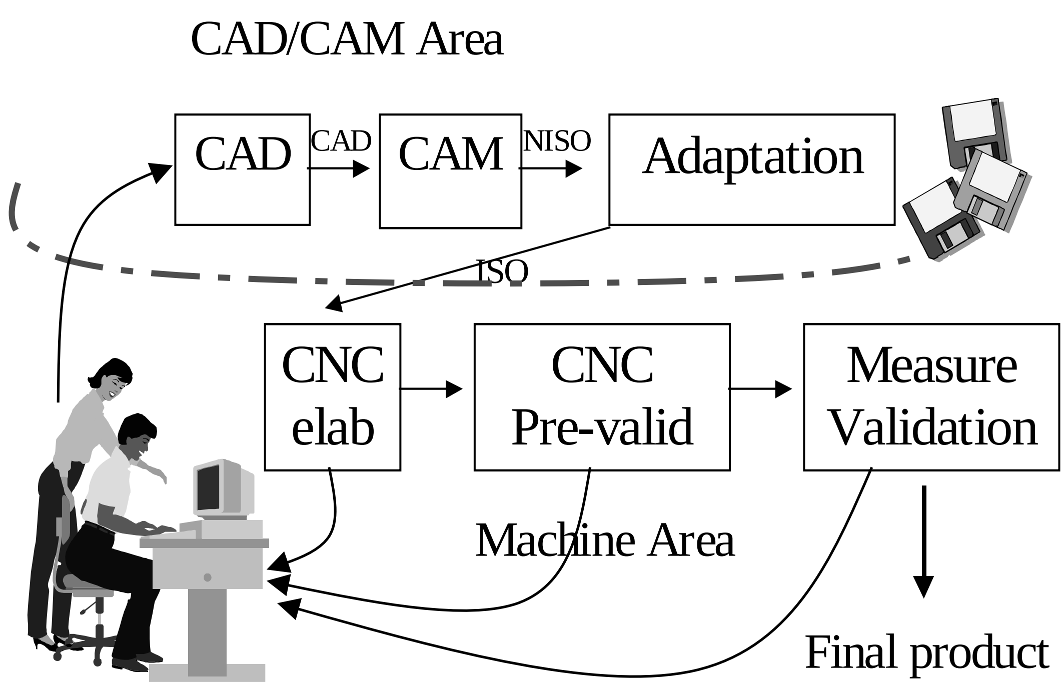
Since long time, in the literature, various low-level communication support have been provided -- e.g., Ethernet, Token Ring, Token Bus, FDDI, ATM, BITBUS, CAN, BACnet, CEBUS, etc. Some of these are typically used for transferring data -- Ethernet, Token Ring, Token Bus, FDDI, ATM, etc... - while the other for control -- BITBUS, CAN, BACnet, CEBUS, IEEE-488, ISP, Lonworks, WorldFIP, ProfiBUS, InterBUS, etc. To this purpose, in literature various protocols for real time distributed systems management there exist.

Despite to the above experiences, the most important CNC builders make possible the interconnection of MTs with a machine playing the role of *production supervisors* through serial connections or "ad-hoc" solutions. It should be noted that the adoption of local networks is not commonly diffuse for implementing DNC policy. Siemens proposes in its catalogue a network based on Ethernet IEEE 802.3 (CSMA/CD) 10 Mbits, which allows to connect several CNCs; it has furthermore defined a high-level protocol (SINEC). Bosch allows the implementation of DNCs by connecting CNCs having interfaces with EDNC, LSV2 protocols, or the simplified

RS232 and RS-422; furthermore PROFIBUS - Field Bus processor standardized according to DIN 19245 standard- is used for data exchange among PLC, also of various producers. NUM (France), FIDIA (Italy), SELCA (Italy), FANUC (Japan), GRUNDIG (Germany), DAIMLER-BENZ (Germany), and ELEXA itself (the coordinator of this project) use Ethernet 2 Mbytes for communicating among CNC with similar results as better explained in the following. As a conclusion, only low bit rates or unreliable supports have been used. This way to work corresponds to the state of the art of the interconnections among machine tools in industrial environments. These communication mechanisms are frequently used for both controls and data, also for establishing a connection between machine tools and CAD/CAM area.

4.1.2 State of the Art : integration between CAD/CAM and MT areas.

In a typical enterprise, there are usually *M* MTs, *M/2* workstations for CAD and *M/2* machines for the execution of CAM and Adaptation applications. The MTs are furthermore supported by robots for charging and discharging pieces and tools from automated storage platforms. These automatic systems of support are usually controlled by the CNC of the MT served. In the working area also Measuring Machines, MEMA, on which templates and final pieces are measured to evaluate the conformity with the starting requirements and hence to validate the template production are present. Template measures are usually checked on the basis of a paper version of the piece. The state of the art about the communications between the CAD/CAM/adaptation environment and the area in which are located MTs/MMs for measuring and producing pieces is carried out off-line through magnetic supports. Only seldom there exist enterprises in which a network support is used to transfer working programmes through FTP. Some of the CNC builders mentioned in the previous section provide a network only for distributing control by using low-band networks and not for transferring to CNCs large quantities of data. This is mainly due to the fact, that a large part of MTs are used for production where the same working programme is executed several times before to pass to a new one. This is confirmed by the fact that they are using Ethernet support.



In the industries producing templates, there exists a strong interest in the integration of CAD/CAM with the factory part in which MMs, measurement systems, robots, etc., are present. The integration must be supported by a fast and reliable communication between these two areas for making available

(i) in real-time working programmes directly on CNCs without transferring them by using magnetic supports or by using slow and unreliable networks,

(ii) the possibility of the remote execution of CAD/CAM/adaptation directly on the CNC console.

The execution of CAD/CAM applications on MM consoles must be supported by mechanisms for dynamic optimization of CAD, CAM and MMs resources.

The same network could be used for delivering commands that are typical of CIM policy (monitoring and planning activities carried out by machines). By using a such network support and general services the CIM policy can be expanded to plan also the CAD/CAM/adaptation activities.

The above mentioned requirements seem to be contradictory since the transferring of working programs in short time (from the CAM and adaptation stations to CNC) needs a high throughput, while the sending of commands in real-time (synchronization commands, alarms, etc.) means high reliability and predictability.

It is in our opinion that these problems can be solved by adopting a fast and reliable supports based on a priority-based protocol such as 100VG, ATM, etc. Even Fast Ethernet (100 BT) if it is carefully used. These are typically problems solvable with HPCN technology. Other networks or control networks are less predictable or too slow (CAN, Token Ring, Lonworks, WorldFIP, PROFIBUS, etc.).

Very few CNCs builders are experiencing communication networks: see the following European conferences: Asi95 (intelligent control and integrated manufacturing systems), CEBIT95 (Information and Communications Technologies Fair) ESPRIT-CIM94 (European Conference on Information Technology, Iim95 (Integration in Manufacturing and the latest SMAU, BIMU and EMO in Milan.

This ICCOC stand alone assessment has been a preparatory study only slightly related with others EC projects such as: PLENT 20723, NetCIM 9901, AITIME 9902. The above mentioned relationship is a mere concept since none of these projects study the solutions for the above described CAD/CAM and MMs areas integration problems, even if these problems are not yet solved as demonstrated by the lack of commercial product provided by CNC builders. In addition, some of the mentioned projects give for granted that these problems exist and have as aim only the definition of the information exchanged among machines. There is a relationship also with the ESPRIT projects: OSACA 6379 (Open System Architecture for Controls with Automation systems) and MOSAIC 5292 (Modular open systems architecture for industrial motion control). The main aim of these latter projects was the definition of flexible distributed architectures at system control level, without solving specific technical interconnection problems in very noisy areas such as workshops, without considering the integration problems between CAD/CAM/adaptive machines and the CNC-based machines.

4.2 Approach

The keys of the project are: High Performance Network, remote execution of CAD/CAM Applications, file transfer, remote execution of CNC and production process optimization. One of the main aim of the project is the creation of a mock-up prototype to validate the feasibility of the project and to validate the solution chosen.

The selection of the most suitable network support was made considering high throughput in critical conditions, physical layer, technology, drivers and development software availability.

Ethernet (IEEE 802.3), Token Ring (IEEE 802.5), Fast Ethernet 100Base-T (IEEE 802.3U), ATM, FDDI, 100VG-AnyLAN (IEEE 802.12) have been evaluated.

Among the mentioned network supports the 100VG and the 100BT have been the most interesting for the performance/cost ratio. ATM and FDDI are too expensive, this is due to the needs of fiber cables and special HUBs. 100 VG AnyLAN is more reliable than 100 BT. In certain conditions even 100BT can be profitably used (bandwidth required ≤ 40 Mpbs and the communication are mainly 1:1). In some special conditions, when high throughput must be guaranteed, specific switches HUB can be used. Most of the tests that have been performed on the network can be replicated on both the supports with minor changes. The operations of remoting, ftping, etc. can be performed on the basis of TCP/IP protocol that is totally independent from the network support used. The previously mentioned facts place the basis for using both network supports. 100 VG and 100 BT uses the same category 5 cables and they have quite the same response to the noise when the Switch HUB is used for 100 BT. HP has decided to remove from the market the 100 VG, it is probable that others 100 VG vendors will increase its price on the market. This will make more interesting the solution based on 100 BT in the next months.

For the tests, a network based on 100VG connected to a 10BT has been used.

The network topology and hardware (wirings type, board models, HUBs, etc.) adopted for the ICCOC project consists in a 100VG HUB connected to several CNC/MM, CNC/MEMA, and CAD/CAM stations having 100VG network adapter and a bridge toward 10Base-T thin Ethernet HUB connected to Unix station (without the 100VG Adapter).

For the Remote execution of CAD/CAM/Applications the best solution seems to be the Remote Window Server Terminal Base. UNIX possesses functions that re-direct the flows of the applications towards a new terminal on the network. For Windows NT, independent software manufacturers have commercialized terminal substitutive (X-Win, X-Win32, Window Based Terminal Server, etc.).

For the file transfer the standard FTP is strongly diffuse and easy to understand, so this is the protocol chosen.

For the Production Process Optimization (monitoring the factory activity and optimizing resources according to simple schedule mechanisms and considering the status of a database containing specific information) the best solution seems to be the Intranet Technology Specific Application. Several intranet techniques for building applications have been proposed.

For the Remote execution of CNC, the full remote control (software applications that allow to remotely acquire the total control of the session excluding the original customer: PC Anywhere, Laplink) or Intranet Technology Specific Application seems to be the better solutions.

Several tests have been performed in order to verify the response in bandwidth and the CPU Utilization during the various tests, for the 100VG network connected to a 10Base-T network for interfacing with a Unix Workstation that provides the CAD and CAM programs. The using of a 10Base-T network for the remoting of the CAD does not limit the results, because, like the tests will demonstrate, the load generated by the remoting is so low that a standard ethernet is sufficient.

In the tests, the typical conditions of the manufactures analyzed have been simulated and the typical operations have been performed. The requirements have been evaluated in an environment rich of electromagnetic noise at TECMA, that plays the role of a typical hand-user in the ICCOC project, in order to create the worst case conditions. In order to create base workload, a couple of programs named NETSERVE (server program) and NETPERF (client program), running under Windows NT, have been used. These programs generate traffic on the HUB (http://www.cup.hp.com/netperf/NetperfPage.html). The running of the above-cited programs on one, two and three couples of CNC stations generates the traffic. The stations that are not used to perform such operation are devoted to test and measure network load. The measure of the load on the HUB is performed by a program provided by HP that requires that the measuring WS is connected to the debug port of the HUB with an RS232 cable.

Referring to the prototype (mock-up), it has been capable of testing the most important features identified before, it must be integrable in the final environment consisting of a set of workstation with both Windows NT and Unix OS. For the development of the prototype, the object-oriented technology has been used. In particular the object-oriented methodology for system development has been used. At level of Management, the methodology of DSI and ELEXA has been applied.

In the Test of Prototype, the prototype and its functionality has been tested. It includes the verification of performance of the network when it is used for remote execution of applications and for transferring large amount of data (such as working programs).

Remote execution is one of the principal applications that will be executed on the network. In the network configuration adopted, the remoting is obtained by the use of a specific terminal programs (e.g. X-WIN Pro of LabTam Corp.) that allows the visualization of a UNIX X Terminal on a CNC, Windows NT based station.

It is very important to measure both bandwidth used on the 100VG HUB and CPU Utilization for CNC Workstations during the execution of the various tests in order to verify the feasibility of operations.

In the test of the Remote execution of the UNIX CAD and visualizing its GUI on ELEXA-CNC, under different three base workload conditions (0, 40 Mbps and 68.4 Mbps), the Unix CAD is remoted on a CNC station, while another CNC station measures the load on the 100VG network. During the remoting of the application the increase in CPU Utilization for CNC is monitored in order to verify the load on the station during the normal future operation.

In the test of the Remote execution of the UNIX CAM with rendering and visualizing its GUI on ELEXA-CNC, under the previously cited different base workload conditions, the Unix CAM is remoted on a CNC station, while another CNC station measures the load on the 100VG network. During the remoting of the application the increment in CPU Utilization for the CNC is monitored in order to verify the load on the station during the normal future operations.

In the Tests about the Possibility of Remotely Control CNC from another CNC (sometimes it’s necessary that a single operator controls more than one CNC; in order to allow this mechanism it’s necessary to remote the console of a CNC on other CNC), the bandwidth necessary to perform such an operation, and the cost, in term of CPU utilization both for client and server CNC, are measured.

In the test about the Transferring Files, we performed a file transfer between two NT workstations and in particular from CNC/MM to CNC/MEMA station. In a second test the files are transferred between a coulpe of stations M1, M2. At the same time M1 requests files from M2 and M2 requests file from M1. The test are made via Unidirectional FTP and via Bidirectional FTP.

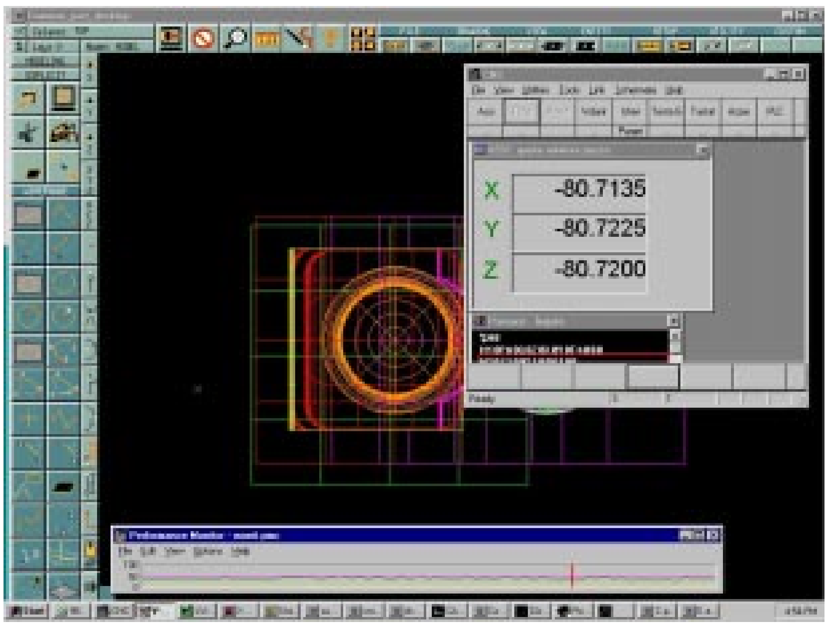
In the tests about the Possibility of Measuring, Planning and Re-Planning, we adopted different workloads on the network simulated by:

- Activation of the remote execution of the CAD;
- Activation of the remote execution of the CAM;

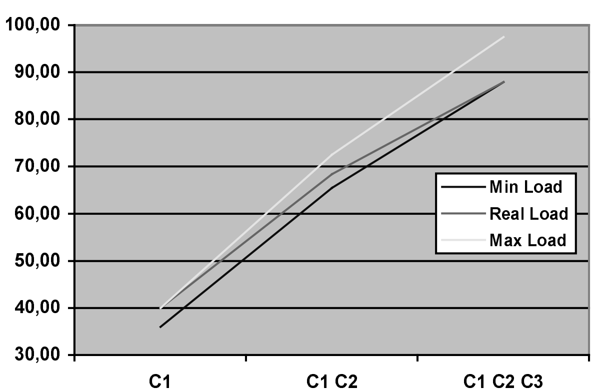
- Activation of the remote execution of an FTP;
- Testing of the client-server architecture of the prototype when several clients are open and operate on the same data;
- Testing of the client-server architecture of the prototype when several clients are open and operate on different data.

By the report of the result we found that:

- The load of the Prototype on the network can be neglected with respect to the other loads
- Remoting is feasible and cheap
- Is also well-considered by End-Users
- Network support chosen is adequate
- Real economical benefits have been detected by end-users



The figure reports a CNC station in which the remote execution of a CAD application has been activated. On the bottom of the figure, the status of of the task monitor of windows NT has been also reported in order to show the load of the workstation.



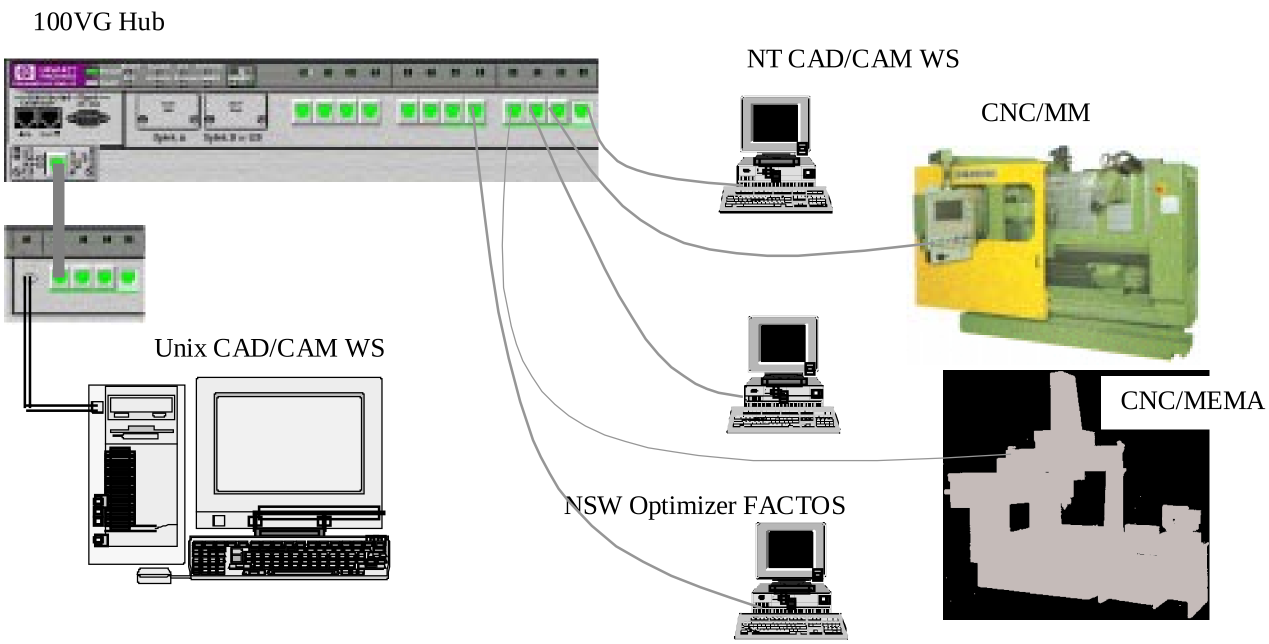
The figure reports the load of the network. In order to measure the effective performance, three couple of machines have been tested separately so to evaluate the maximun load on the HUB. The HUB has been guaranteed to have at least 90% efficiency under any workload conditions. C1, C2, C3: the three couples versus the load shown in Mbps.

4.3 Results

In this paragraph are summarized the main results, achievements and benefits obtained by this project.

4.3.1 Network

The network topology that has been adopted for the ICCOC project consists of a 100VG HUB connected to several CNC/MM, CNC/MEMA, and CAD/CAM stations having a 100VG network adapter and a bridge toward 10Base-T thin ethernet Hub connected to Unix station (without the 100VG Adapter). The topology is presented in the following figure.



The hardware components used for the 100VG network used are summarized in the following table.

Hub	HP J2415A – AdvanceStack 100VG Hub-14
Bridge	HP J2414B HP 100VG/ET SNMP/Bridge Module
Transceiver	HP J2608 ThinLan
Network Adapter	HP J2585B DeskDirect 10/100VG PCI LAN Adapter
Cables	UTP Cat. 5
Connectors	RJ-45

The other components are a classical 10Base-T HUB with both RJ-45 and BNC connectors connected to the Bridge Transceiver of the 100VG Hub, the internal network adapter of the Unix WS connected to the 10Base-T Hub with a Thin coaxial with the standard BNC connector.

4.3.2 The Mock-Up Prototype

A mock-up prototype (also called FACTO) to validate the assumption made was implemented. It consists in a distributed application designed and implemented by using object-oriented technology, in particular the object-oriented methodology for system development will be used. At level of Management, the methodology of DSI and ELEXA will be applied.

The main tasks the prototype accomplish are:

1. *Activation of the remote execution* of CAD/CAM/Adaptation workstations on CNC and MEMA machines.
2. *Activation of file transfer* from the machine containing the file(s) and that which has to used it.
3. *The possibility of Monitoring and Measuring* in real-time the activity of the factory and that of its components.
4. *The possibility of Planning and Re-Planning* in real-time of the activities of CAD, CAM, Adaptation workstations, CNC and MEMA machines.

The two last points are based on the assumption of building a FACTO Server to organize schedule and make the all services that are available on the network to the several Clients. For these reasons, FACTO can be considered a sort of mechanism for virtualizing the services that are available on the network. The FACTO Server could be located in a machine dedicated to its execution. The Clients are located on CAD/CAM/Adaptation Workstations, on CNC, and on MEMAs. The ICCOC prototype can be considered the early demonstrator of FACTO architecture comprised of a Server and a set of possible Clients.

FACTO provide an User Interface for:

- FTP sessions. It is the basic network operation in CNC environment. Prototype grants:
    - Commands simplification: Ftp transfer requires a rigid command succession that can be totally automated to allow working time saving.
    - Security: prototype, by automatic localization and transfer, grants a selective access to files and directories to assure safety of other CNC operations.

- Start CAD, CAM and measurement software remote operation: Prototype would open the remote session in the available network host by a simple button click.

The main results abtained by the prototype are that remoting UNIX applications on Windows NT is quite simple by using one of the several products for remoting X Terminal on Windows NT. Remoting Windows NT Applications on Windows NT can be done in several manners -- e.g., by using PCAnywhere, LapLink. By using the Window Based Terminal Server (the so called Hydra) which is currently under beta-test and will be included into the Windows NT 5.0 for Servers. Moreover, remoting Windows NT Applications on UNIX is possible by using special applicative programs, and also remoting UNIX applications on UNIX is not a problem by using X terminal.

Referring to the file transfer, this is really simple since all UNIX and Windows NT machines can used FTP based on TCP/IP.

FACTO is a prototype for future operations like:

- Automatic optimization of resource with a real time scheduling algorithm.
- Monitoring in real time of all task time and of all working deadlines.

In order to realize FACTO Java 1.1.4 of SUN Microsystem has been adopted. Java has been selected among the most diffused language for the features it can collect:

- Java is easy to learn and easy to use;
- Java is Object Oriented;
- Several Just in Time Compiler are available to compile the code in native microprocessor code machine;
- Java is portable over a large number of different platforms, and in particular under most diffuses Unix and Windows NT: WS using different operating systems can use the same server program without modification.

- Java has several native classes for supporting distributed systems Remote Method Invocation (RMI) and interface Object Request Broker (ORB) for the accessing to Object Oriented Databases. These features have permitted to create on the server object which methods are executed directly by the clients.
- Java can execute code in native language (like C++) thanks to JNI. In Windows NT JNI allows the interface between Java and C++ DLL that can run native 32 bit applications.

4.3.3 Results

The prototype has been tested in real conditions at TECMA together with the test of network and of several other details about the integration.

Tests about Remote Execution

Remote execution is one of the principal applications that will be executed on the network. The remoting is obtained by the use of a specific terminal programs (e.g. X-WIN Pro of LabTam Corp.) that allows the visualization of a UNIX X Terminal on a CNC, Windows NT based station.

It is very important to measure both bandwidth used on the 100VG HUB and CPU Utilization for CNC Workstations during the execution of the various tests in order to verify the feasibility of operations.

Remote execution of the UNIX CAD and visualizing its GUI on ELEXA-CNC

In this test, under different three base workload conditions (0, 40 Mbps and 68.4 Mbps), the Unix CAD has been remoted on a CNC station, while another CNC station measures the load on the 100VG network. During the remoting of the application the increase in CPU Utilization for CNC has been monitored in order to verify the load on the station during the normal future operation. During this test the NC program is not running on CNC machine.

When Numeric Control (NC) Program is not running:

HUB Base Workload	0 Mbps	40 Mbps	68.4 Mbps
Load on The HUB	0.6 Mbps	40.6 Mbps	69 Mbps
Max Cpu Utilization	20%	20%	20%

When NC is running:

HUB Base Workload	0 Mbps	40 Mbps	68.4 Mbps
Load on The HUB	0.6 Mbps	40.6 Mbps	69 Mbps
Max Cpu Utilization	40%	40%	40%

Remote execution of the UNIX CAM with rendering and visualizing its GUI on ELEXA-CNC

During this test, under the previously cited different base workload conditions, the Unix CAM has been remoted on a CNC station, while another CNC station measures the load on the 100VG network. During the remoting of the application the increment in CPU Utilization for the CNC has been monitored in order to verify the load on the station during the normal future operations. During this test the NC program is not running on CNC machine.

When Numeric Control (NC) Program is not running:

HUB Base Workload	0 Mbps	40 Mbps	68.4 Mbps
Load on The HUB	0.6 Mbps	40.6 Mbps	69 Mbps
Max Cpu Utilization	20%	20%	20%

When NC is running:

HUB Base Workload	0 Mbps	40 Mbps	68.4 Mbps
Load on The HUB	0.6 Mbps	40.6 Mbps	69 Mbps
Max Cpu Utilization	40%	40%	40%

Tests about the Possibility of Remotely Control CNC from another CNC

Sometimes it's necessary that a single operator controls more than one CNC. In order to allow this mechanism it's necessary to remote the console of a CNC on other CNC.

This test allows measuring of the bandwidth necessary to perform such an operation, and the cost, in term of CPU utilization both for client and server CNC.

When NC is not running:

HUB Base Workload	0 Mbps	40 Mbps	68.4 Mbps
Load on The HUB	0.1 Mbps	40.1 Mbps	68.5 Mbps
Max Cpu Client Utilization	15%	15%	15%
Max Cpu Server Utilization	5%	5%	5%

When NC is running on client:

HUB Base Workload	0 Mbps	40 Mbps	68.4 Mbps
Load on The HUB	0.1 Mbps	40.1 Mbps	68.5 Mbps
Max Cpu Client Utilization	35%	35%	35%
Max Cpu Server Utilization	5%	5%	5%

When NC is running both on client and server:

HUB Base Workload	0 Mbps	40 Mbps	68.4 Mbps
Load on The HUB	0.1 Mbps	40.1 Mbps	68.5 Mbps
Max Cpu Client Utilization	35%	35%	35%
Max Cpu Server Utilization	25%	25%	25%

Tests about the Transferring Files

The first test performed consists in transferring files between two NT workstations and in particular from CNC/MM to CNC/MEMA station. In the second test the files have been transferred between a coulpe of stations M1, M2. At the same time M1 requests files from M2 and M2 requests file from M1.

Unidirectional FTP: in this test several files have been transferred. This test measures performance of file transfer between two 100VG Windows NT based workstations. Several files have been transferred and the mean Transfer Rate and the load on the network, under two different base workload conditions, have been measured.

Base Workload	28.8 Mbps	61 Mbps
Transfer Rate	7.4 Mbps	7,8 Mbps
HUB Load	36.8 Mbps	68.85 Mbps
Overhead on the HUB for each FTP session activated	< 2%	< 1 %

Bidirectional FTP: in this test several files have been transferred, but both the stations have been involved in FTP:

Base Workload	28.8 Mbps
Transfer Rate CNC1	7.5 Mbps
Transfer Rate CNC2	7.4 Mbps
Mean Transfer Rate	7,46 Mbps
HUB Load	46 Mbps
Overhead on the HUB for each FTP session activated	< 2.5 %

Tests about the Possibility of Measuring, Planning and Re-Planning

The optimization program FACTO (client program) did not generate a measurable load, because the throughput on the network was less than 0.1 Mbps. This client program did not not provide a Cpu load greater than 2% on the less performing machine used in the network. The load on the network and the Cpu usage have been due to the remoting of CAD, CAM or FTP.

The mean measured response time of the client, when some client concurrently send query to the server, is about inversely proportional to the number of clients issuing queries.

Comments about Remote Execution Tests

Examining the results of all the previously presented tests and considering that the Execution of Windows NT provoke a maximum load of 2% on the Cpu, it is evident that a single CNC machine is able to perform all the operations tested at the same time. The percentage of Cpu that it is necessary to run CNC program is 20%, to remote a CAD is 20% (for CAM is 30%) and to remotely control another CNC station is 15%. When all the operations (NT+CAM+CNC Client+CNC Server) are performed at the same time, the total load on the Cpu is (2% + 20% + 30% + 15%) less than 70% and, therefore all the Cpu resources are not used. The load on the network is very low because each station that performs all the previously cited operation, generate a load less than 1 Mbps.

Comments about FTP sessions

This test demonstrates that about 6 bi-directional FTP session can be activated at the same time without collapsing the network.

The project has been completed and the work performed has demonstrated the faithfully and the strong interest of such a product. This opinion is shared by TECMA and from other contacted end-users.

The solutions adopted in the mock-up prototype, implemented for the ICCOC project, can be profitable adopted as tested on the field. We found that:

- Remoting is feasible and cheap
- Remoting Is well-considered by End-Users
- Network support chosen is adequate

- Real economical benefits have been detected by end-users

The benefits evaluated are:

- Reduction of costs for Re-CAD and Re-CAM: 60%
- Reduction of time for Re-CAD and Re-CAM: 20%
- Optimization of production process: saving 20%
- Re-qualification of “CNCer”

Thus a New Product and a New Market will be set.

The above opinions are shared by TECMA and from other contacted end-users.

4.4 Dissemination

4.4.1 Demonstrations

Some demonstrations have been given at TECMA; several other demonstrations are planned in order to verify if the requirements collected by visiting the end-users have been correctly interpreted.

An open-house will be organized as soon the suitable machines will be available in Florence, probably in October.

4.4.2 Dissemination Material

- Early version of WWW pages at http://www.pdc.kth.se/pdcttn/machinery/ and http://www.pdc.kth.se/pdcttn/machinery/factory.html. Please see also the local page located in http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html
- 70 Commercial Slides

4.4.3 Publications

- An article at the CSMR'98, IEEE, EUROMICRO,
- An article on Meccanica di Qualita' e Macchine, DeQualitate Magazine 1998 (1)

4.4.4 Contacts With End-Users

OMCS,	B-Ticino,	BVA,
Cevolin,	CB-Ferrari	CALP,
SL,	IMES	MPT,
Lucchese Stampi	Zago,	SMP

On The Basis of the Early Prototype some Concrete Agreements for implementing ISLANDs including ICCOC capabilities:

FABOHA (Germany) ELSATECH (Italy) ZAGO (Italy)

4.5 Conclusions

The key elements for building new products and for going towards an actual integration of the factory are:

- Remote execution of CAD, CAM, ADP, on CNC/MM and CNC/MEMA
- Monitoring the activity of the factory
- Planning and re-planning the activity in order to optimize the process of production.

So the aspect of Islands integration (MTs/MEMAs/Robots) and CAD/CAM/CNC integration must be integrated.

The ICCOC project has been focussed on CAD/CAM/CNC Integration.

The whole view is going to be obtained by merging the results of ICCOC with those obtained by ELEXA on Islands.

The solutions adopted in the mock-up prototype, implemented for the ICCOC project, can be profitable adopted as tested on the field. We found that:

- Remoting is feasible and cheap
- Is well-considered by End-Users
- Network support chosen is adequate
- Real economical benefits have been detected by end-users

The Costs for the real implementation of the mock-up prototype have been estimated about 900 d/m (concretely predicted on the basis of ICCOC feasibility study 15 classes x 3 x 20 days)

The benefits estimated are:

- Reduction of costs for Re-CAD and Re-CAM: 60%
- Reduction of time for Re-CAD and Re-CAM: 20%
- Optimization of production process: saving 20%
- Re-qualification of "CNCers"

Thus a New Product and a New Market will be set.

The above opinions are shared by TECMA and from other contacted end-users:

OMCS,	B-Ticino,	BVA,
Cevolin,	CB-Ferrari	CALP,
SL,	IMES	MPT,
Lucchese Stampi	Zago,	SMP

Several other demonstrations are planned in order to verify if the requirements collected by visiting the end-users have been correctly interpreted

On The Basis of the Early Prototype some Concrete Agreements for implementing ISLANDs including ICCOC capabilities:

FABOHA (Germany)	ELSATECH (Italy)	ZAGO (Italy)

This work will place also the basis for studying suitable policies for optimizing the exploitation of resources of the factory (CAD, CAM, CNCs, etc: a distributed application for optimizing the exploitation of the resources in the factory: Measuring, Planning and Re-Planning in real-time of the activities of CAD, CAM, Adaptation workstations, CNC and MEMA machines..). The implementation of the algorithms of resources optimization and managing could be the subject of a bigger proposal and project in the same applicative domain.

Distributed application for optimizing the exploitation of the resources in the factory: Measuring, Planning and Re-Planning in real-time of the activities of CAD, CAM, Adaptation workstations, CNC and MEMA machines.

4.6 Contact Details

Contact Person: Marco Perfetti
ELEXA S.r.l.
(Project Coordinator, HPCN technology consumer: CNC builder)
Via delle Panche, 38 A, I 50141, Firenze, Italy
Phone: +39-55-43.51.19
Fax: +39-55-43.76.334
E-mail: elexa@tin.it

Contact person: Paolo Nesi
DSI (Department of System and Informatics)
(HPCN Technology provider)
University of Florence,
Via S.Marta, 3 A
I-50139 Firenze - ITALY
tel. +39 55 47.96.523
fax: +39 55 47.96.730
e-mail: nesi@dsi.unifi.it
WWW: http://www.dsi.unifi.it/~nesi

Contact person: Massimo Giorgetti
TECMA S.r.l. (End user: factory for producing templates)
Viale XX Settembre, 78
I-50019 Sesto Fiorentino, Firenze, ITALY
Phone: +39-55-44.42.41
Fax: +39-55-44.42.41

Some data about the project
Start: 15 July 1997 --- End: 15 Feb. 1998
Duration: 6 months
Total Costs: 58310 ECUs
Total Funding: 29155 ECUs (50%)
Man/year: 0.631

5. APPENDIX A

A synopsis slide for the ICCOC project.

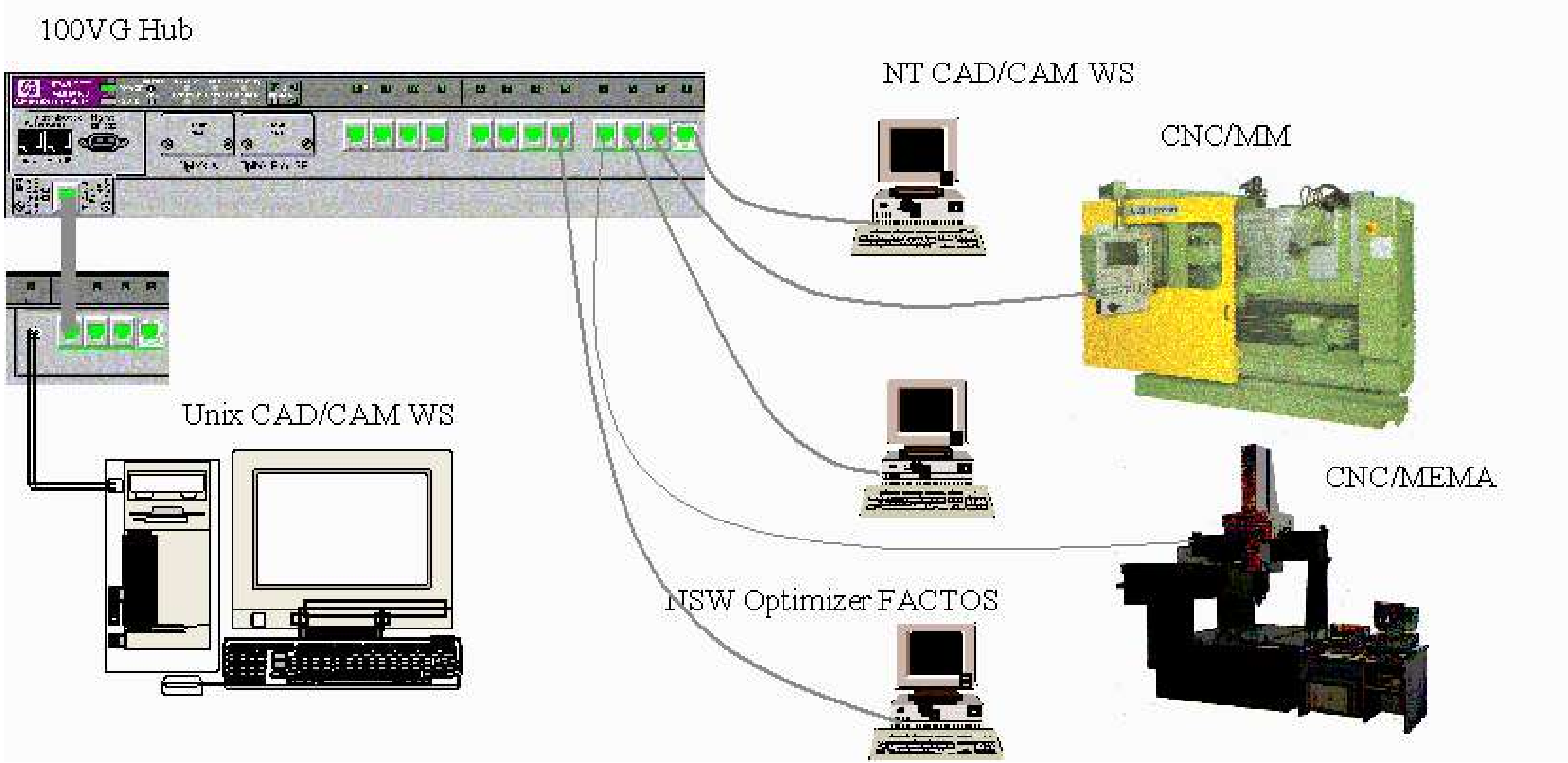
The ICCOC Project

- Business case
  - *In the field of production of templates there is a strong demand for a better integration between CAD/CAM area and the machines area*
  - *objective of the project is the use of high performance computing for optimizing processes of production and the integration of the factory resources*
- Business benefits
  - *reduction of time for producing templates and optimization of production costs*
- Results obtained
  - *the reduction of costs for Re-CAD and Re-CAM operations: 60% reduction of time for Re-CAD and Re-CAM: 20, optimization of production process: saving 20%,*
  - *CNC users can access CAD/CAM applications directly from the CNC console*

ELEXA Point of View

ELEXA builds Computerized Numerical Controls for Milling Machines, MMs, for making templates in unique pieces with very high precision of finishing on the machine. Templates are typically defined on CAD/CAM stations but their design must be frequently customized changing shape, and CAM parameters. This need leads to a heavy exploitation of CAD/CAM stations for considering issues strictly related to MMs, these are in turn very far from the CAD/CAM user mind-set. MMs for templates have to change, as fast as possible, their working program for each piece. Moreover, the description of these templates in terms of working program is very heavy since they must be produced with a high precision and this lead to have very large working programs -- e.g., several tenths of megabytes. Precision, also means to have very specialized and costly MMs. The pieces are defined on CAD/CAM stations but their design must be frequently customized changing shape, and CAM parameters. This need leads to a heavy exploitation of CAD/CAM stations for small and MMs-related issues that are in many cases very far from the CAD/CAM user mind-set. For these reasons, some builders have decided to integrate on CNCs for MMs also operations partially performed on CAD/CAM stations. For example, the visualization of working program (both in graphics and statements forms) for obtaining a specific mechanical piece, the implementation of coarse working programs on the basis of simple graphic editors. In the enterprises, which base their economy on producing templates, it is necessary to reduce as much as possible the time during which the machine does not work -- i.e., from the working of a template to the next one -- the so called dead time of MM.

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html


100VG Hub
NT CAD/CAM WS
CNC/MM
Unix CAD/CAM WS
CNC/MEMA
NSW Optimizer FACTOS

Test about Remote Execution

Remote execution is one of the principal applications that will be executed on the network. The remoting is obtained by the use of a specific terminal programs (e.g. X-WIN Pro of LabTam Corp.) that allows the visualization of a UNIX X Terminal on a CNC, Windows NT based station.

It is very important to measure both bandwidth used on the 100VG HUB and CPU Utilization for CNC Workstations during the execution of the various tests in order to verify the feasibility of operations.

Remote execution of the UNIX CAD and visualizing its GUI on ELEXA CNC

In this test, under different three base workload conditions (0, 40 Mbps and 68.4 Mbps), the Unix CAD has been remoted on a CNC station, while another CNC station measures the load on the 100VG network. During the remoting of the application the increase in CPU Utilization for CNC has been monitored in order to verify the load on the station during the normal future operation. During this test the NC program is not running on CNC machine.

When Numeric Control (NC) Program is not running:

HUB Base Workload	**0 Mbps**	**40 Mbps**	**68.4 Mbps**
Load on The HUB	**0.6 Mbps**	**40.6 Mbps**	**69 Mbps**
Max. Cpu Utilization	**20%**	**20%**	**20%**

When NC is running:

HUB Base Workload	**0 Mbps**	**40 Mbps**	**68.4 Mbps**
Load on The HUB	**0.6 Mbps**	**40.6 Mbps**	**69 Mbps**
Max. Cpu Utilization	**40%**	**40%**	**40%**

Remote execution of the UNIX CAM with rendering and visualizing its GUI on ELEXA-CNC

During this test, under the previously cited different base workload conditions, the Unix CAM has been remoted on a CNC station, while another CNC station measures the load on the 100VG network. During the remoting of the application the increment in CPU

Utilization for the CNC has been monitored in order to verify the load on the station during the normal future operations. During this test the NC program is not running on CNC machine.

When Numeric Control (NC) Program is not running:

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Max. Cpu Utilization	**40%**	**40%**	**40%**

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

Test about the Possibility of Remotely Control CNC from another CNC

Sometimes it's necessary that a single operator controls more than one CNC. In order to allow this mechanism it's necessary to remote the console of a CNC on other CNC.

This test allows measuring of the bandwidth necessary to perform such an operation, and the cost, in term of CPU utilization both for client and server CNC.

When NC is not running:

HUB Base Workload	**0 Mbps**	**40 Mbps**	**68.4 Mbps**
Load on The HUB	**0.1 Mbps**	**40.1 Mbps**	**68.5 Mbps**
Max. Cpu Client Utilization	**15%**	**15%**	**15%**
Max. Cpu Server Utilization	**5%**	**5%**	**5%**

When NC is running on client:

HUB Base Workload	**0 Mbps**	**40 Mbps**	**68.4 Mbps**
Load on The HUB	**0.1 Mbps**	**40.1 Mbps**	**68.5 Mbps**
Max. Cpu Client Utilization	**35%**	**35%**	**35%**
Max. Cpu Server Utilization	**5%**	**5%**	**5%**

When NC is running both on client and server:

HUB Base Workload	**0 Mbps**	**40 Mbps**	**68.4 Mbps**
Load on The HUB	**0.1 Mbps**	**40.1 Mbps**	**68.5 Mbps**

Max. Cpu Client Utilization	**35%**	**35%**	**35%**
Max. Cpu Server Utilization	**25%**	**25%**	**25%**

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

Test about the Transferring Files

The first test performed consists in transferring files between two NT workstations and in particular from CNC/MM to CNC/MEMA station. In the second test the files have been transferred between a couple of stations M1, M2. At the same time M1 requests files from M2 and M2 requests file from M1.

Unidirectional FTP: in this test several files have been transferred. This test measures performance of file transfer between two 100VG Windows NT based workstations. Several files have been transferred and the mean Transfer Rate and the load on the network, under two different base workload conditions, have been measured.

Base Workload	**28.8 Mbps**	**61 Mbps**
Transfer Rate	**7.4 Mbps**	**7,8 Mbps**
HUB Load	**36.8 Mbps**	**68.85 Mbps**
Overhead on the HUB for each FTP session activated	**< 2%**	**< 1 %**

Bi-directional FTP: in this test several files have been transferred, but both the stations have been involved in FTP:

Base Workload	**28.8 Mbps**
Transfer Rate CNC1	**7.5 Mbps**
Transfer Rate CNC2	**7.4 Mbps**
Mean Transfer Rate	**7,46 Mbps**
HUB Load	**46 Mbps**
Overhead on the HUB for each FTP session activated	**< 2.5 %**

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

Results

Tests about the Possibility of Measuring, Planning and Re-Planning

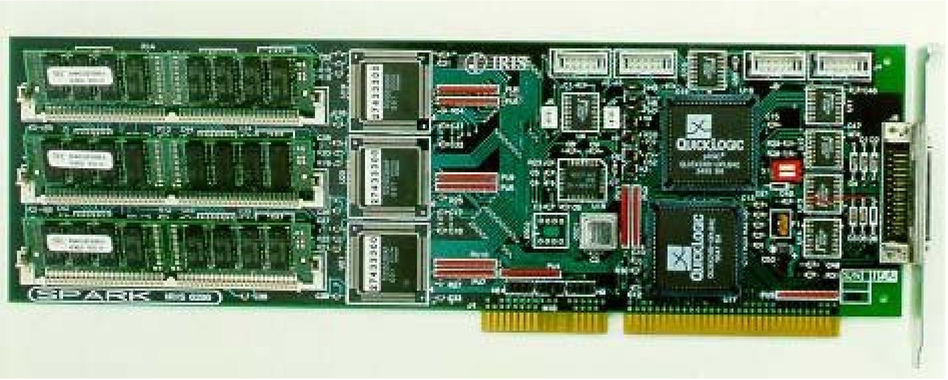
The optimization program FACTO (client program) did not generate a measurable load, because the throughput on the network was less than 0.1 Mbps. This client program did not not provide a Cpu load greater than 2% on the less performing machine used in the network. The load on the network and the Cpu usage have been due to the remoting of CAD, CAM or FTP.

The mean measured response time of the client, when some client concurrently send query to the server, is about inversely proportional to the number of clients issuing queries.

ICCOC URL: http://aguirre.dsi.unifi.it/~hpcn/wwwiccoc/wwwpag.html

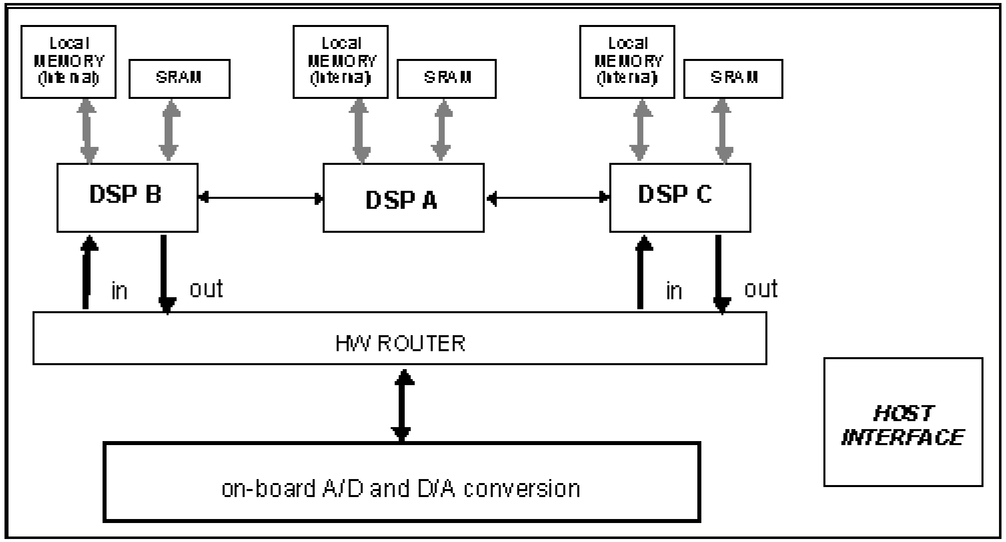
SPARK prototype system

A high-performance parallel computing architecture for sound spatialization has already been developed in the form of a single board prototype by IRIS, the SPARK board. SPARK has already been tested by two selected users, Tempo Reale of Florence (by allowing electronic music composers to use multiple loudspeakers in their realizations), and CRM (Centro Ricerche Musicali) of Rome, to investigate in the field of sound spatialization.



The SPARK system is based on a sinchronous multiprocessor architecture using IRIS custom-designed digital signal processing units. Each DSP board is based on three custom DSPs connected in a synchronous configuration and operating in parallel at full speed. The total aggregate computing power is 150 MIPS (peak) per board, and on-board interconnection bandwidth reaches 26 Mbit/s.

All A/D and D/A conversions are performed on-board. Furthermore, the microprogram assortment and software support is very limited. The SPARK concept has been extensively tested in many situations and it has proved itself very powerful and promising.



Architecture of the SPARK prototype system

Market Situation

Most of the public events see thousand people attending live concerts inside stadiums, theatres, discos where is needed to compensate delays caused by the positioning of the loudspeakers around large areas and to obtain a high level of involvement from the attendance.

Without considering the incredible amount of stadiums as locations for events, every year, in Europe take place about 1000 important live concerts, there are more than 3000 main theatres, and 20 national television networks. Any of them could get benefits by I'M EASY technology.

The Television standard recently migrated to stereo transmissions, where it is possible to encode surround information. It should be noted that producers and directors look more for involving people in high intensity events by using visual effects, which have to get correct positioning inside the three-dimensional audio space. To obtain such a kind of results any technical problem related to the specific area where the event has to be reproduced, must be easily solved by the spatializer system itself.

According to our market analysis, performed by interviewing sound engineers, post-producers directors, musicians, mastering, none of the products on the market is fully satisfactory:

- The existing spazialization and/or surround systems in the market do not match completely the professional expectations like easy installation, management on mixing consoles or on personal computers. None of the products on the market can offer a whole of real-time operations, dynamic automation of each single source from and to the audio matrix and mixer, fully automatable functions controlled by joysticks or MIDI controllers.

- Plug In software like PT3D Spatializer, Dolby Surround Tools and Sigma 1 are related to specific audio cards installed only on Macintosh computers, other stand alone systems like DSS are nowadays obsolete concepts.

- Post-production facilities need to develop their projects on systems matching and even advance the newest industry requirements. DVD and DV-Audio protocols provide for archiving and reproducing surround matrix, or audio on 6 or more channels. According to those new standards post-producers had to rule their investments on appropriate technology.

These are the reasons why I'M EASY will be developed: an exhaustive system for spatialization, real-time automation of every single audio source, dynamically controllable from the major standard controllers and timecodes as requested by important prompters as well the partners in this project GOIGEST, IRIS, RIGEL, A&G and others.

Current Operational Way

There are several hardware and/or software based systems to enlarge stereo images, spatialize, create surround matrix. Most of the them are based on physical commands like buttons or sliders that operate on mixing consoles which still are mixers for audio and not specific products oriented to the audio spatialization.

In these cases the user has to assign one the incoming sources to a channel, then to a send to reach one or more points of a matrix which will redistribute the sound on the desired outputs. The routing and assignation commands involve several steps to reach the desired positioning. In addition to that, even the most recent consoles have only small LCD displays, which force the user to jump from one window to another. These procedures cause a chain of steps not at all quick and comfortable. The less expensive console-carrying feature allowing to program surrounds costs about 2.000 ECUs and does not match exactly the requirements for a handy and fast operative tools.

Actual professional software for 3D, spatialization, and surround are mainly software "Plug Ins" based on Apple Macintosh computers for specific, expensive audio systems. This software offers in general a helpful user interface, are easy to understand and can be driven by mouse and/or commands from the keyboard. The cost of a single application is about 1.500 ECUs, but cannot work without being installed on proper computer based digital audio cards. The necessary hardware for the computer costs around 9.000 ECU. In any cases they partially cover the requirements, in that none of them joins the capabilities of software based product with instantaneous physical controllers.

Moreover, there has never been a spatializer system able to manage several audio sources in real time and, in the meanwhile, to be slaved to synchronisation signals like SMPTE, MTC, and BIPHASE.

Taking into account the above points and considering that:

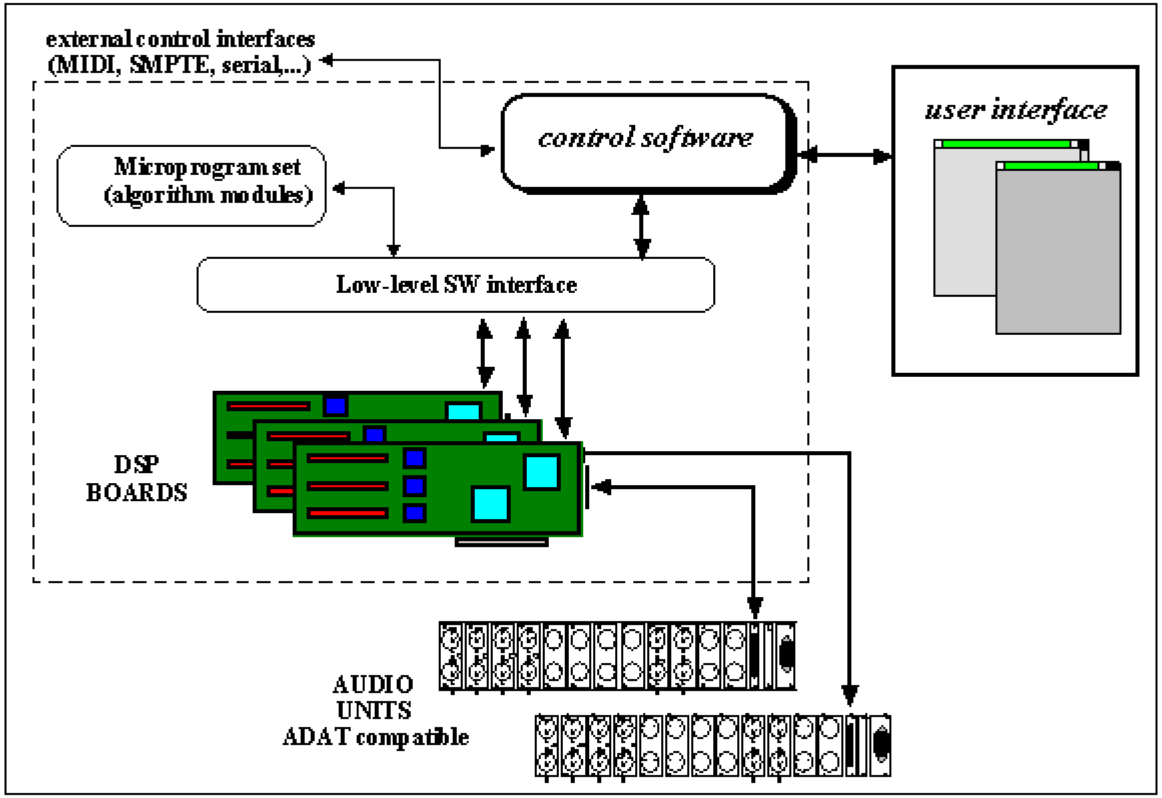
- DSI has already implemented object-oriented music editors and lecterns for both single musicians (LIOO application) and director/archivist (MSLIOO application). Moreover, DSI has experience in decoding MIDI files
- IRIS has the hardware technology related to audio signal processing coming from the realisation in 1989 of the first Italian DSP custom chip, the X20. This technology has been, then, used to generate a family of microchips entirely dedicated to audio processing like the K22, that equipped in the years 1993-1997 the new family of FARFISA professional keyboards (F and G series), and the N22, a new 32 bit fixed point DSP that will be used in the I'M EASY board for sound elaboration and spatialization.
- Rigel Engineering has the know-how and the experience of advanced software development related to multimedia research and innovation. The company also has a strong background on development related to audio processing, for example, within the field of the speech synthesis with the product MyVoice
- A&G and GOIGEST both have the know-how and the practical experience on the field, starting from audio professional business market till the artistic production and realisation of live concerts and theatrical performances.

These facts and the maturity of the HPCN technology produce the opportunity for introducing such a technology in a new environment (the orchestras, theatres, recording studios, etc.) for building an audio spatialization system.

ARTEC GROUP and A&G have a specific interest in distributing I'M EASY systems, as well as smaller products derived from I'M EASY parts in both national and international markets. A&G and ARTEC GROUP knows very well the market of Computer Music, A&G has a worldwide commercial network as Distributor of Computer Music Products.

I'M EASY architecture overview

A prototype of I'M EASY architecture for sound spatialization will be implemented, by using HPCN technologies relative to parallel architectures. The implementation of the I'M EASY prototype involves both hardware and software aspects.



The components of I'M EASY architecture, where the dotted line specifies the components related to the project, are:

1. DSP board: it is a multiprocessor board to be installed in a PC-compatible computer, and it is based on a special-purpose digital signal processors AD SHARC 21065L, totally dedicated to the processing of audio signals; multiple boards can be directly interconnected in various configurations.

2. Audio unit: it will be independent of the life of the product. The audio unit can support communication standards, such as ADAT, and , with a newer version, some other professional standard such as TASCAM. In this way, the product could be distributed separately even to customers that already own such a unit.

3. Microprogram module set: it is the collection of algorithms to be tailored on the SHARC assembler and board architecture, following the slot-organized architecture of the multiprocessor DSP board; the microprogram modules implement all the necessary processing functions, for both spatialization and conventional

sound processing.

4. Low-level interface: it is the set of libraries that implement an interface layer between host and DSP boards, taking care of the initialization procedure relative to the DSP boards and the audio units, and taking into account the asynchronous communication approach of the AD SHARC 21065L DSP.

5. Control software: it is the application that provides a consistent and complete environment in which it will be possible to handle the whole system, including automation capabilities, dynamic and static reconfiguration, cue list handling, external synchronization.

Note that the data exchange capability with the host PC functionality will grant the compatibility with other Pro Audio products, such as Digi-Design.

The host software set is composed of three elements, which are:

The microprogram module set

This is the heart of the whole system, implementing all the necessary algorithms to process input signals. The microprograms take advantage of the highly partitioned structure of the custom DSPs, and are hand optimized to ensure maximum performance. The main blocks have already been developed and field-tested in their basic functionality on the SPARK board. To enter the commercial market, more microprogram modules are needed, in order to offer a large set of options to the customer. Furthermore, the existing modules must be modified following the high level specifications of the I'M EASY architecture. A custom interactive programming environment is already available for the custom DSPs.

The low-level software drivers

To control the system, a library to access all the functionality of the boards will be developed. This library will depend on the specifications of the entire system. The software library currently employed has been developed mainly for testing and debugging purposes and has to be revised.

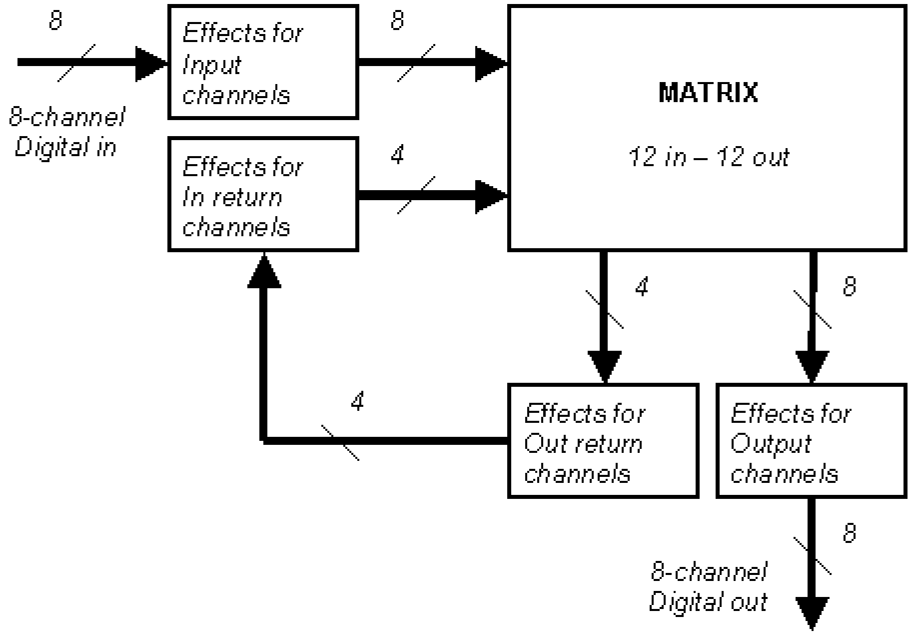
The control software

Being a reconfigurable, time-slot division multiprocessor system (multiple boards are employed, each board with 4 processors), the task of handling the current configuration of the system is not trivial. Furthermore, typical audio applications dictate the need to partially change the current configuration without introducing audible artifacts (clicks, pops, interruption of sound) into the active processing paths. This requirement strongly influences the structure of the control software layer.
Its main tasks will be: dynamic reconfiguration of parameter sets, algorithms and control structures; parameter typing; real-time specialized control of selected parameters in response to external control sources; handling of control sources (MIDI, RS-232, RS-422); handling of external synchronization protocols (MTC, SMPTE, VTC); and automatic assignment of resources (time slots, internal and external connections).

The DSP level

From a logical point of view, the DSP level architecture can be described as follows:

- 8 physical input channels
- 12 input channels with a logical input patch-bay
- a 12 X 12 gain matrix
- 12 logical audio output channels
- 8 physical output channels
- 24 effect processor, one for each input channel and one for each output channel.



The EZ-SOUND board will use these DSP resources as follows:

1. selects 12 logical audio inputs from the input patch-bay
2. processes each audio input using one effect processor
3. sends each one of the processed input signals to a "row" of the gain matrix
4. the gain matrix re-scale each input 12 times with 12 independent SW controllable weights, and accumulate the result on the 12 gain matrix output channels ("columns")
5. each one of the 12 gain matrix output is sent to an output effect processor

6. the output of each one of the 12 output effect processors is used as final output of the board.

The source of each one of the 12 audio inputs of the board will be SW configurable and will be selectable from:

- 8 -channel Digital inputs
- effect return lines
- host supplied audio signal as multimedia drivers and audio plug-ins.

The 12 audio outputs of the board will be used in this way:

- each one of the first 8 audio outputs is sent to a digital output
- up to four selectable audio outputs can be sent to an effect send line
- all the audio output can be used as input signal for host software like multimedia drivers and audio plug-ins.

The availability of host supplied input and outputs audio signals has to be considered only as an architectural specification introduced with the goal of offering an open feature for future enhancement of the EZ-SOUND software. The implementation of audio drivers and plug-ins is not part of the I'M EASY project.

Each one of the effect processor will consist of:

- an input gain
- a graphic equalizer
- a delay.

The input gain will be smoothed by the DSP chips. This means that the high level software can change it without worrying about noises ("click"). The input gain can also be negative: this results in a phase inversion of the signal.

The graphic equalizer will consist of:

- a low pass filter with variable cut-off frequency
- a high pass filter with variable cut-off frequency
- a band pass/reject filter with variable frequency, bandwidth and gain.

The delay processor is currently under project. As the board can access a large memory range, the maximum delay time will have to be scaled considering the impact of the cost of the memories on the final cost of the board.

The gain matrix will consist of 144 accumulation nodes organised into 12 rows, one for each input, and 12 columns, one for each output. Each node will have a software controllable gain. The gain is smoothed in order to avoid "clicks".

The Control Level

The control level software is a set of two libraries:

- EZSOUND library: a C++ library containing low level functions needed to access all of the board resources,
- EZSPACE library: an intermediate C++ library, based on services supplied by the previous one, which implements the spatialisation algorithms by controlling the relative gains on the matrix.

These libraries allow to interact with the upper and lower software level. The libraries will allow the higher software level to access more than one board at a time. If more than one board will be controlled from the same user interface, that is if a multi-board application will be implemented, the coherence of the behaviour of the boards is assured by the high level software.
The multi-board approach will allow adding an extra feature to the system: modularity. There are some practical situations in which 8 physical inputs and 8 physical outputs are not enough. A host computer containing more than one EZSOUND board can manage these situations by simultaneous interaction with all the boards.

The API contained in these libraries will be implemented so as to a high-level 32-bits development environment like Visual Basic 6 or C++ can easily call them.
The data formats used as parameters are those typical of 32 bit developing systems for Windows 95.

The EZSOUND library

EZSOUND low-level library manages:

- all the requirements to access the resources of a memory mapped, PCI standard and Plug'n'Play standard compliant board;
- the initialisation (boot) of the board from host, that is the firmware loading on the four DSP, and the initialisations of all the needed parameters;
- the installation and the management of a bi-directional message based communication layer between the host and one or more of the DSP processors;
- services destined at the highest software level, to access firmware resources through specific functions of the particular DSP application.

EZSOUND library has been implemented as a 32 bit Windows dynamic link library EZSOUND.DLL containing:

- the management of the PCI Plug n' Play interface to the board,
- the "multi-board" logic, that is the management of a spatialisation session, which uses more than one board,
- all the functions needed to initialise and control the board resources,
- all the functions needed to interact with the DSP chips,
- the interface (API) to the upper level.

The API will supply functions to allow the host computer to:

- initialise a board,
- manage the input channel assignment from the input patch-bay,
- control the 24 effect processors parameters,
- control the 144 gains of the gain matrix,

- send one or more host generated audio signal to the processing section by using a virtual player,
- receive one or more audio signal coming out from the processing section by using a virtual recorder.

The board access functions provide for multi-board applications, i.e. they allow access to many boards at the same time.

The EZSPACE library

EZSPACE libraries implement the spatialisation mechanism. It will be initialised by the high level program with all the information needed on the actual loudspeaker set configuration, including the Cartesian co-ordinates of the loudspeakers. Then the high level software will supply, at runtime, the position to all the sound sources. The position of both the loudspeakers and sound source is expressed as three-dimensional co-ordinates. The library use all these information for computing the relative gain of a source through a loudspeaker.
As there is no commonly accepted "good" spatialisation algorithm, this library has been separated from the EZSOUND, the low level library. In this way, it is simple to develop and test different algorithms. Moreover, updating a single library do not effect the other.

The EZSPACE.DLL library manages the computing and gain setting for all matrix nodes and offers a set of higher level functions for sound spatialisation.

Different spatialisation algorithms are under testing, to investigate the possibility of allowing the user to choose between different ones.
The spasialisation mechanism will use the following input data:

1. The description of the loudspeaker configuration consisting of the number of loudspeakers. For each loudspeaker the following data are provided:
    - The loudspeaker position (x, y, z);
    - The position of a point (different from the loudspeaker position) laying on the irradiation axis of the loudspeaker. This is needed to calculate the loudspeaker orientation;
    - An attenuation graph expressed as function of the irradiation angle;
    - An attenuation graph expressed as function of the distance from the loudspeaker.
2. The position (x, y, z) of each sound source.

    The information of the loudspeaker configuration will be supplied by the high level software, once for each performance. The position of the sources will be updated at run time when the position changes. There is no need for a very high update rate, as the smoothing mechanism included in the DSP level will interpolate between different positions in time.

While a detailed study about the best set of available spatialisation algorithms is expected, a very simple one has been implemented in order to test the software architecture. It only uses:

1. the Cartesian co-ordinates of the loudspeaker
2. the Cartesian co-ordinates of the sound sources
3. the distance factor of the loudspeaker, which is different for each loudspeaker. It specifies how fast the gain will decrease if the distance between sound source and loudspeaker increases.

The algorithm consists of calculating the square of the distance between the sound source and the loudspeaker, and raising the distance factor to the distance power. As the distance factor is less than 1, the gain will decrease while the distance increases.
This is not a complicated algorithm as it does not take care of loudspeaker directionality and does not use a correct mathematical model of the physical situation, but it is

very simple and does not use much CPU time. A test of this algorithm, running on the SPARK board, has given acceptable results, so it is one of the candidates for the final application.

High Level Control Application

The I'M EASY high level control application (HLCA) is the visible part of the spatialization system and it is the main interaction component. Among others, the main features are:

- Definition of a virtual 3D room or stage as the base of the spatialization system
- Full interaction in the 3D environment: Top view, Left view and 3D view
- Possibility to move and drag elements in the space, to draw directly in the space the input source trajectories and to move interactively an input source without trajectory (hence spatializing the sound of that source) while other input sources are in running mode
- Editing of the single trajectory step (position, timecode)
- Hierarchy-ordered elements to split session in more usable parts
- Handling a session, scenes, inputs and outputs
- Saving and restoring all the user performed spatialization works in IMEASY document format
- Defining special sound effects for the input that the user has chosen
- Comparing and eventually reorganizing the timing of trajectories via a time scheduler
- Playing mode to activate the spatialization board

(Click on the image to know more about the functionalties of I'M EASY related to the corresponding screenshot)

Main Window

Input source positioning

Drawing a sound trajectory

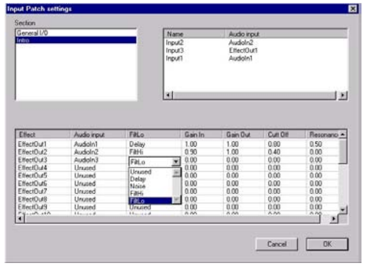
Another view of the sound trajectory

Full views of the trajectory

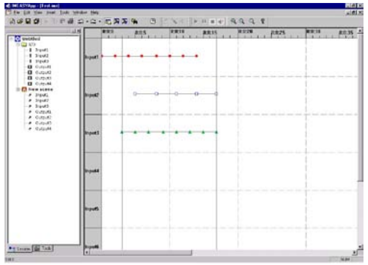
Drawing trajectories with different views

Trajectories defined

Source properties



Input patch setting



Time scheduler

Playing mode

The HLCA will be installed by the I'M EASY user, with the help of a standard installation set of media, manuals and the EZ-SOUND board. The installation will be modular, meaning that user will be able to tailor the high-level control application according to his needs.First, the user will install the audio spatialization board in one of the available slots of the I'M EASY workstation. Next, the user will run the installation utility to copy the high-level control application on the I'M EASY workstation hard disk.

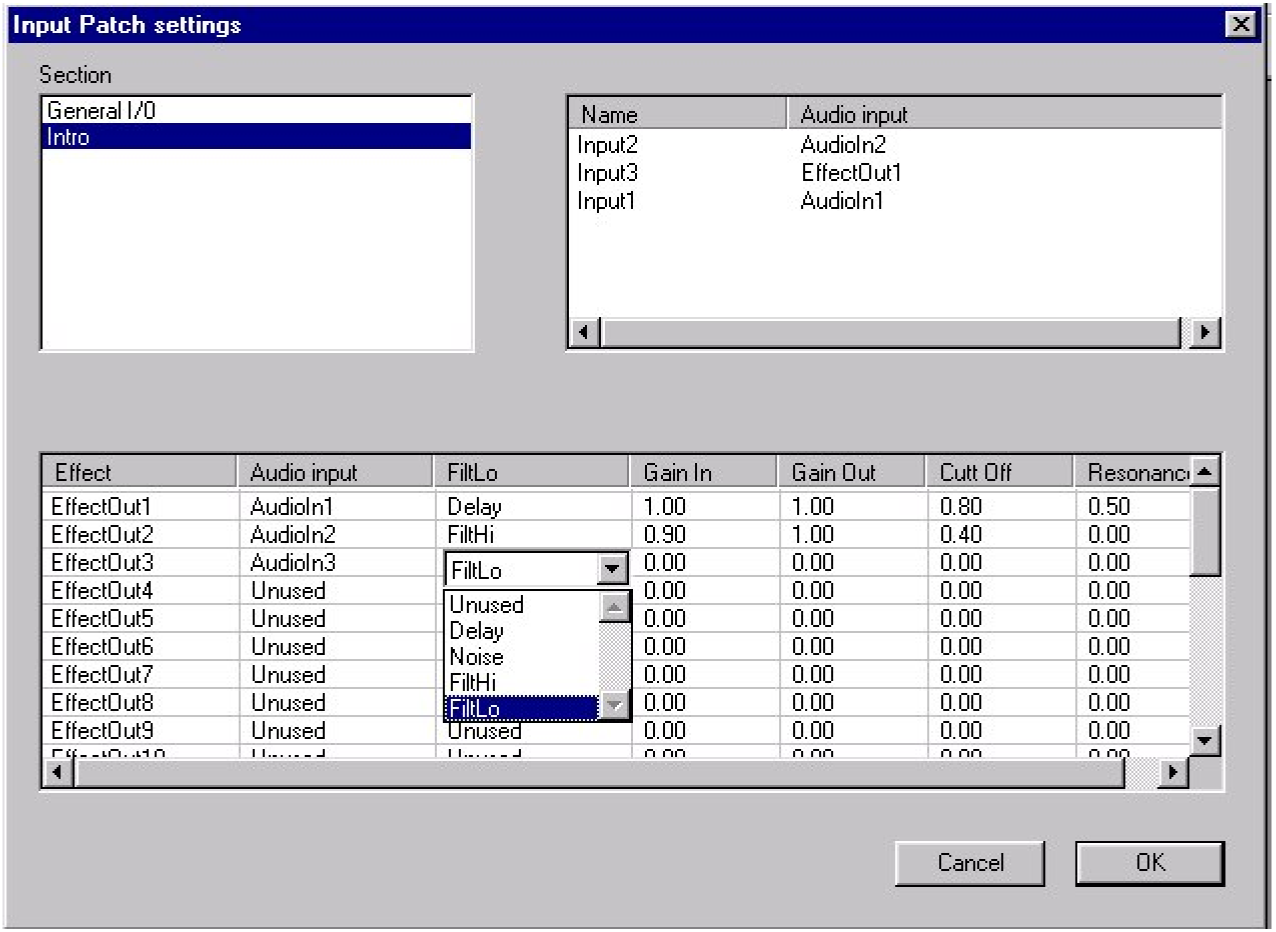
HLCA requirements

The requirements of the high-level control application at the user inteface level are:

- Sound source handling
- In and out source testing
- Outputs mastering
- Mixing
- Session handling (workspace and sessions)
- Scenes handling
- 2D drawing of the stage map
- Creation of a sound source path over the stage
- 3D stage maps handling

Input patch setting

It is possible to define special sound effects for the input the user has choosen. Each virtual input can be associated to an Audio input (from board or from file), as well as to an Effect generated from an Audio input.

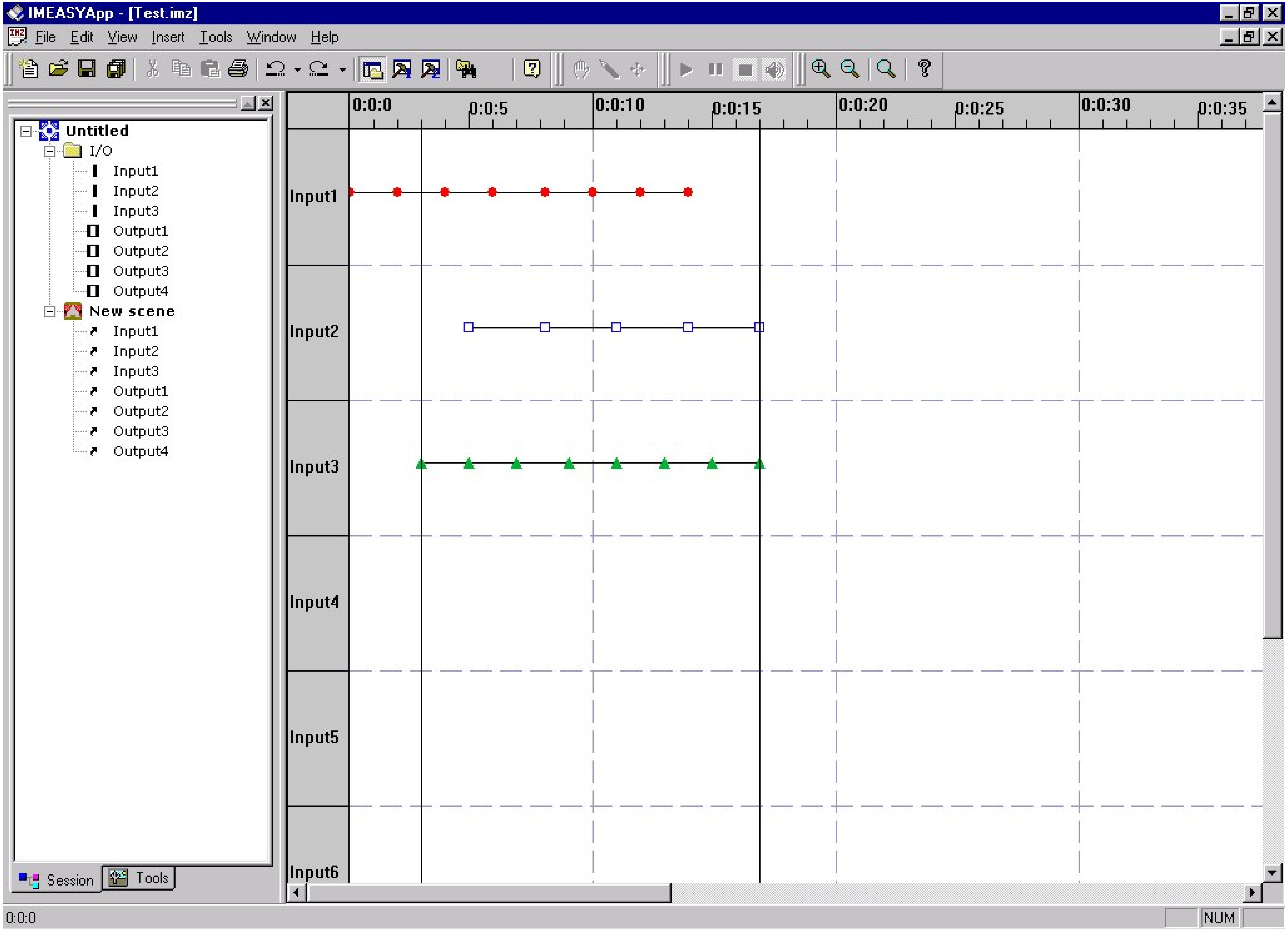


Time scheduler

When all the trajectories are inserted in the scene, the user may need to see the planned scene from the time point of view. A tool that makes a temporal snapshot of the session and permits the user to compare and eventually reorganise the trajectories seems to be really useful.
The Time Scheduler is a window located on the "views" field of the Main Window. It can share the "views" filed with the 3D scene, but when it is selected, the system changes the control set and shows the zoom palette. On the top of the Time Scheduler, the temporal axis is present and its scale changes together with the zoom level selected.
For each input, the task of this tool is to show the temporal distribution of the trajectories nodes and to move the trajectories along the time. When a trajectory is selected (to select a trajectory click with the mouse on the trajectory) at the beginning and at the end of the trajectory, two lines are drawn. These lines show when the trajectory begins and ends. They are useful to compare the selected trajectory with the others or, when the user moves it, the lines show immediately the new time position.

In this example, three inputs are reported in the Time Scheduler. The "Input 3" is selected and it is clear that its trajectory begins after three seconds that the session is started and terminates, together with the "Input 2" trajectory, at seventeen.

Screen 11


IMEASYApp - [Test.imz]
File Edit View Insert Tools Window Help
Untitled
I/O
Input1
Input2
Input3
Output1
Output2
Output3
Output4
New scene
Input1
Input2
Input3
Output1
Output2
Output3
Output4
Session
Tools
0:0:0
0:0:5
0:0:10
0:0:15
0:0:20
0:0:25
0:0:30
0:0:35
Input1
Input2
Input3
Input4
Input5
Input6
0:0:0
NUM