Sistemi Distribuiti
Corso di Laurea in Ingegneria

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PARTE 10: **.net Remoting**

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Distributed Applications

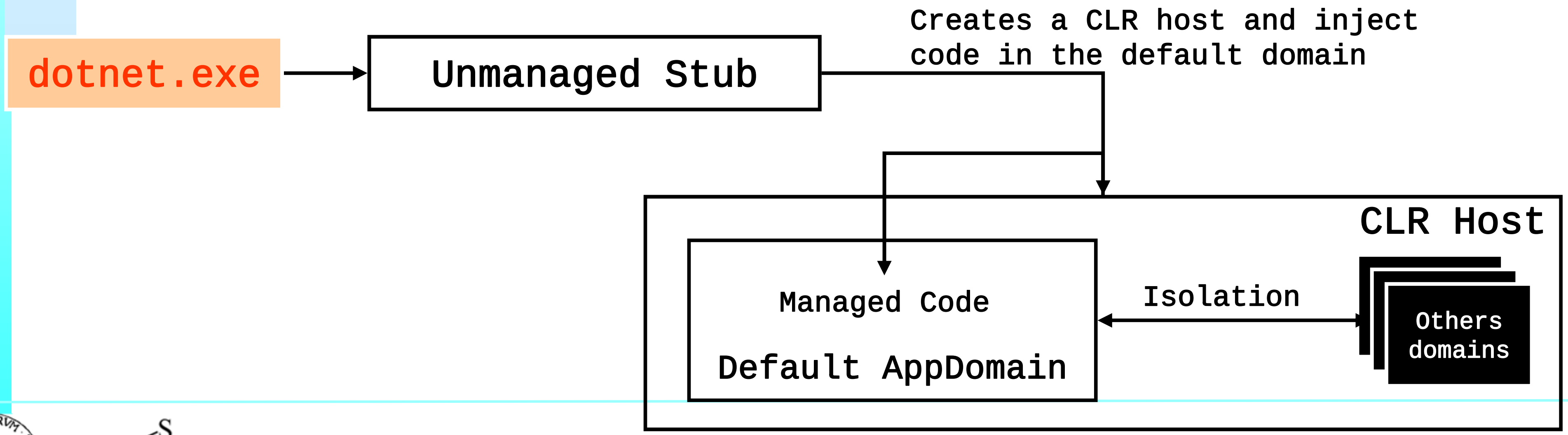
- Intranet model
  - .NET Remoting
  - .NET to .NET
- Internet model
  - Web services
  - HTTP to HTTP
  - Ad hoc services for .NET clients

.NET Remoting

- Set of services that enable applications to communicate
  - Applications can reside on the same computer
  - On different computers in the same LAN
  - Across the world in "very" different networks and running on heterogeneous platforms
- Enable communication between objects in different AppDomains or processes
  - Different transportation protocols
  - Different serialization formats
  - Object lifetime schemes
  - Modes of object creation

AppDomains

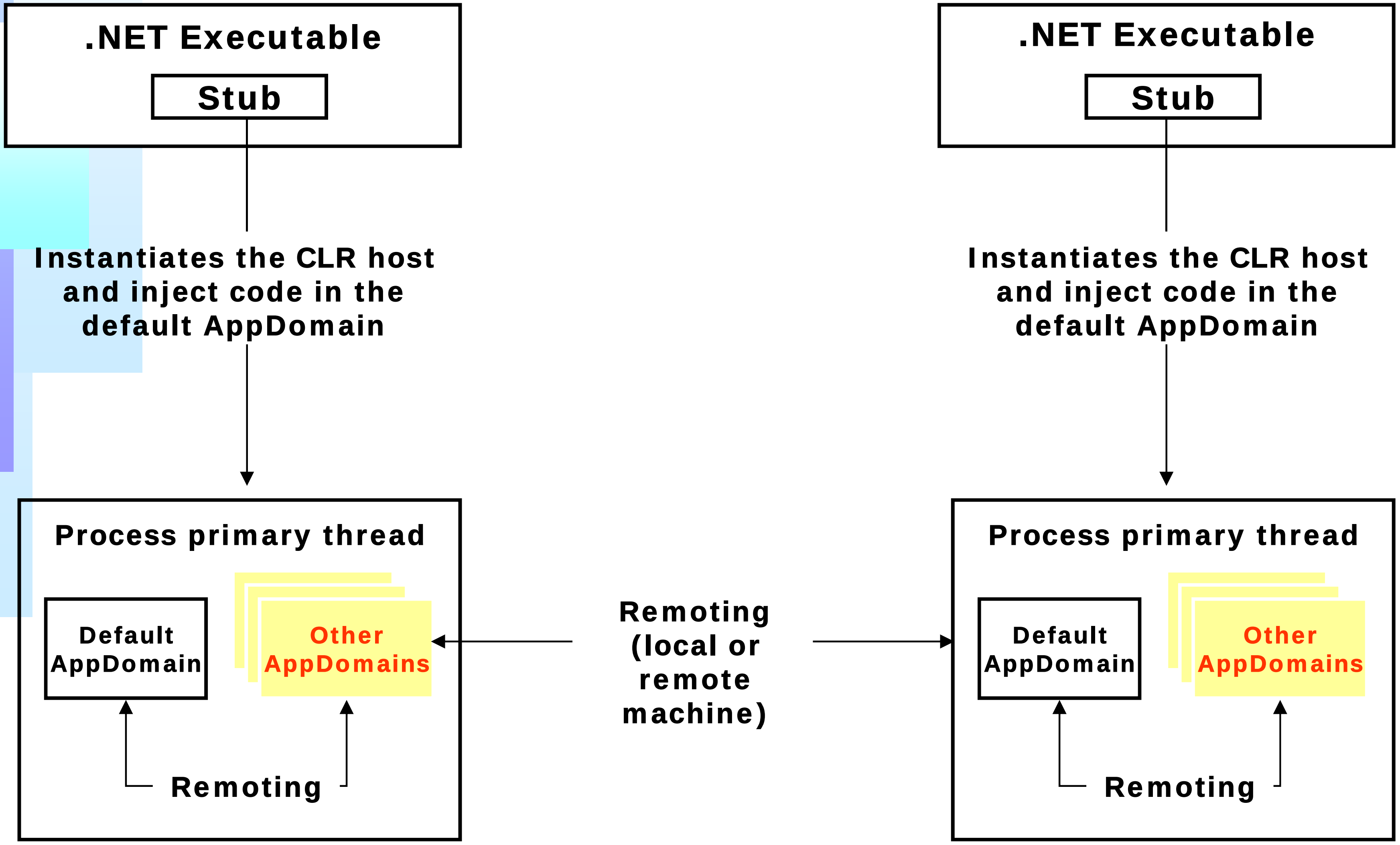
- Managed code runs in an application domain
- AppDomains are separate units of processing that the CLR recognizes in a running process
- AppDomains are separated from one another
  - Similar to process boundaries but more lightweight



Isolation

- Managed code must get through a verification process before it can be run
  - Code that passed the test is said to be type-safe
- The certainty to run type-safe code allows the CLR to provide a level of isolation as strong as the process boundary, but more cost-effective
- The CLR enforces isolation by preventing direct calls between objects in different AppDomains
- .NET Remoting refers to the set of system services to access objects between domains

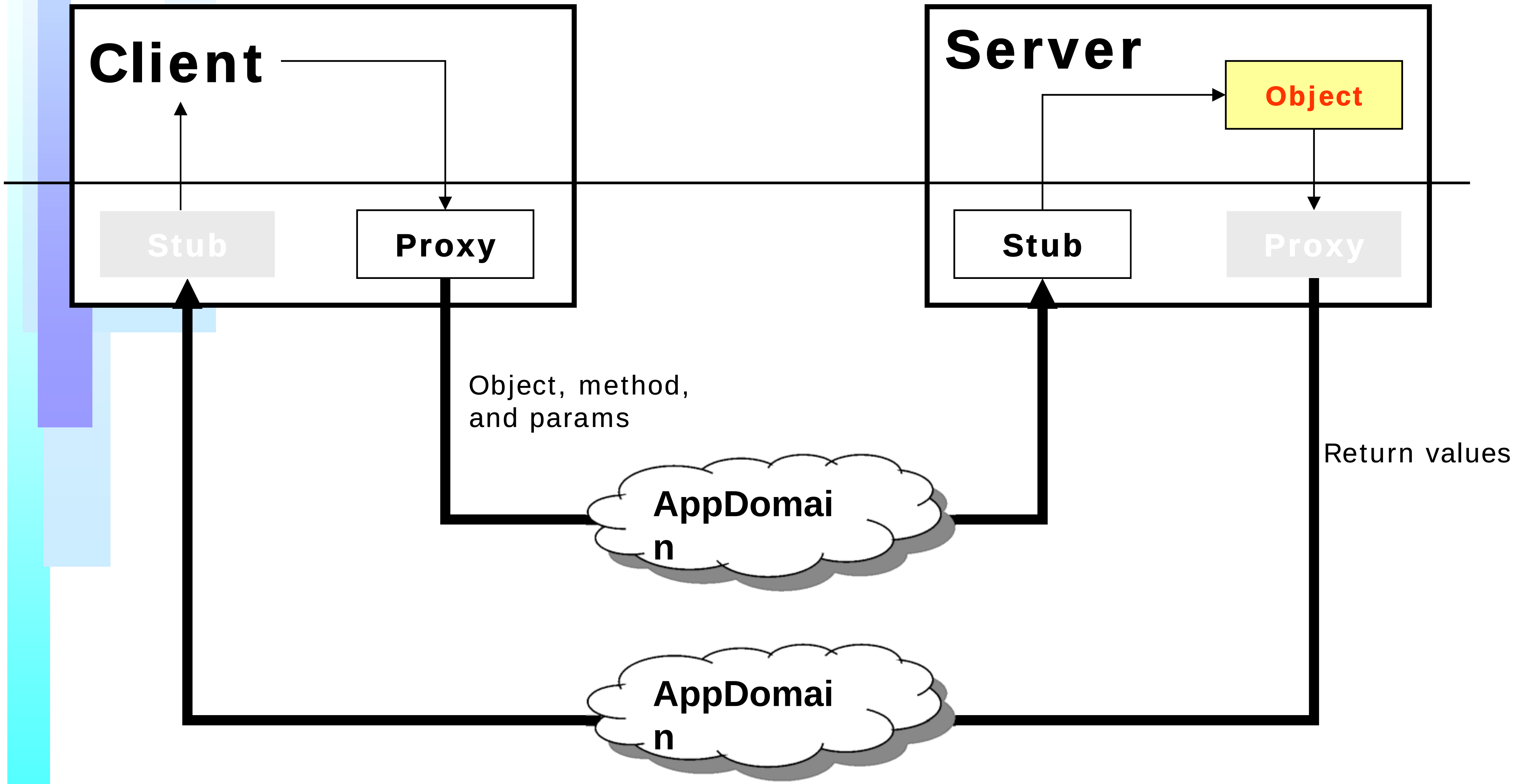
Remoting and AppDomains


.NET Executable
Stub
Instantiates the CLR host and inject code in the default AppDomain
Process primary thread
Default AppDomain
Other AppDomains
Remoting
Remoting (local or remote machine)
.NET Executable
Stub
Instantiates the CLR host and inject code in the default AppDomain
Process primary thread
Default AppDomain
Other AppDomains
Remoting

Marshaling

- Marshal by value
  - Object is instantiated on the client and filled with data coming from the server
  - State of the object downloaded
- Marshal by reference
  - The object lives on the server and any calls take place remotely
  - Input parameters and return value travel over the network

MarshalByRef



Remote Components

- Class derived from MarshalByRef
- Public methods
- Work with serializable classes
- Application Host
  - IIS, NT service, custom app
  - Requires manual activation
  - Publish your components

Client Applications

- Need a reference to the server component
- Mark the remote type as "well-known"
  - Tell the run-time the type lives remotely
  - JIT compiler adds code on-the-fly to transform local calls into remote calls
  - Everything happens transparently
- Instantiated through operator new (*if client activated*)

Serializable objects

- When runtime can make a copy of the object, an object can marshal-by-value to other AppDomains
  - Add **SerializableAttribute**
  - Or implement the **ISerializable** interface

```
[Serializable]
Class Foo {
   . . .
}
```

- Clients in foreign AppDomains receive clone

MarshalByRef objects

- When the object's class derives, directly or indirectly, from **MarshalByRefObject**, the runtime creates a proxy to the object

```
[Serializable]
class Foo : System.MarshalByRefObject {  // MBRO overrides
   . . .                                 //  Serializable
}
```

- Clients in foreign AppDomains receive proxy
- How does a client specify what proxy?

Typical Remoting scenario

- Clients must connect to servers
  - Server needs to publish an object
    - I listen on this TCP channel and that HTTP channel
    - I have a service called "MathService"
    - When client connects to MathService using a supported channel, give the client [a | this] Calculator instance
  - Clients need to specify the desired object
    - Connect to the "MathService" on server "LightningFast" using protocol HTTP on port 80

Writing a server

- Assumption: You have an assembly containing MarshalByRefObject types you wish to make available for use via remoting
- A server then becomes simply a host app
  - Loads the managed types
  - Configures remoting to expose the types
- Can write your own host
- Can use IIS as an already available HTTP host

Server design and implementation

- Design considerations
  - Decide which channels/ports to support
  - Select an activation model
  - Decide how clients get type metadata
- Implementation
  - Select/write appropriate host
  - Configure remoting system activation mode
  - Register channels

Channels

- A channel transports messages to and from a remote object
  - A server selects the channels upon which it listens for requests
  - A client selects the channels it wishes to use to communicate with the server
- Runtime provides built-in channel types
  - HTTP and TCP channels
  - You can write custom channels

ChannelServices.RegisterChannel

```
using System.Runtime.Remoting;
using System.Runtime.Remoting.Channels;
using System.Runtime.Remoting.Channels.Http;
using System.Runtime.Remoting.Channels.Tcp;
. . .
ChannelServices.RegisterChannel (new HttpChannel());
ChannelServices.RegisterChannel (new TcpChannel(4242));
```

Activation requests

- Server also chooses how it wants to process activations requests for a type
- Two forms of server activation
  - WellKnownObjectMode.SingleCall
  - WellKnownObjectMode.Singleton
- One form of client activation
  - Client activated object (CAO)

SingleCall objects

- Server's remoting layer creates one SingleCall object per method call
  - Each object services one and only one request
    - Created on-demand as method calls arrive
    - Lifetime limited to method call
- Useful in stateless applications
- Best choice for load-balanced applications

Singleton objects

- Server's remoting layer creates one Singleton object
  - Sole object handles method calls from all clients
    - Lifetime equals server lifetime
- Useful in stateful applications
  - Can only store *client-independent* state
- Best choice where overhead of creating and maintaining objects is substantial

Client activated objects

- Server activated is one activation model
- Client activated is quite different
- Each client activation creates one object
  - Object's lifetime extends until the earliest event:
    - Client drops reference to object
    - Object's lease expires
  - Similar to COM coclass activation semantics
  - Can store per-client state, receive constructor args

Lease based lifetime

- Client activated object's lifetime controlled by a lease on the object
  - Leases have a lease time
  - Remoting infrastructure drops reference to object when lease expires
- Each method call renews the lease
  - Use default renew on call time
- Clients can renew the lease using the proxy
- Sponsors can renew the lease

Well-known objects

- Server activated types are "well-known"
  - Server tells remoting
    - Here's a type
    - Here's how and when to instantiate the type
    - Here's the name (end point) a client will use to contact the type
  - Clients tell remoting
    - Connect to this server machine
    - Get the (known) type at this end point (name)

Well-known objects

- Server registers a well-known type using **RegisterWellKnownServiceType** specifying
  - The type being registered
  - The end point name known to clients
  - The activation model

RegisterWellKnownServiceType

```
using System.Runtime.Remoting;
. . .
WellKnownServiceTypeEntry WKSTE =
 new WellKnownServiceTypeEntry(typeof(WiseOwl.Calculator),
                           "EphemeralCalc",
                           WellKnownObjectMode.SingleCall);

RemotingConfiguration.RegisterWellKnownServiceType(WKSTE);
```

Server activation example

```
using System;
using System.Runtime.Remoting;
using System.Runtime.Remoting.Channels;
using System.Runtime.Remoting.Channels.Http;
using System.Runtime.Remoting.Channels.Tcp;

class RemotingHost {
  static void Main(string[] args) {
    RemotingConfiguration.ApplicationName = "WiseOwlMathService";
    WellKnownServiceTypeEntry WKSTE =
      new WellKnownServiceTypeEntry(typeof(WiseOwl.Calculator),
                                    "SharedCalc",
                                  WellKnownObjectMode.Singleton);

    RemotingConfiguration.RegisterWellKnownServiceType(WKSTE);
    ChannelServices.RegisterChannel(new HttpChannel(9000));
    ChannelServices.RegisterChannel(new TcpChannel(4242));
    Console.ReadLine();
  }
}
```

Well-known object URLs

- Server-activated objects are published at a URL
  - The URL is "well-known" to the client
    - Such types are called well-known types
    - The URL is called the well-known object URL

```
ProtocolScheme://ComputerName:Port/PossibleApplicationName/ObjectUri
```

- When IIS is the server's host:
  - PossibleApplicationName becomes virtual dir name
  - ObjectUri should end in ".rem" or ".soap"
- A TcpChannel requires the port number

Remoting config file

- All hard-coded remoting information in prior example can reside in external config file
  - Default filename is executable plus ".config"
  - E.g. RuntimeHost.exe is RuntimeHost.exe.config
- Host must tell remoting to use the config file
  - RemotingConfiguration.Configure (file)
- Server code simplifies…

Server remoting config file

```
<configuration>
  <system.runtime.remoting>
    <application name="WiseOwlMathService">
      <service>
        <wellknown mode="SingleCall" type="WiseOwl.Calculator,MathObjects"
                   objectUri = "EphemeralCalc" />
        <wellknown mode="Singleton" type="WiseOwl.Calculator,MathObjects"
                   objectUri = "SharedCalc" />
      </service>
      <channels>
        <channel port="9000" ref="http" />
        <channel port="4242" ref="tcp" />
      </channels>
    </application>
  </system.runtime.remoting>
</configuration>
```

Registering Client Activated Objs

- Server registers a client activated type using **RegisterActivatedServiceType**
  - Specifies the type being registered

```
using System.Runtime.Remoting;
. . .
ActivatedServiceTypeEntry ASTE =
 new ActivatedServiceTypeEntry(typeof(WiseOwl.Calculator));

RemotingConfiguration.RegisterActivatedServiceType(ASTE);
```

Client activation example

```
using System;
using System.Runtime.Remoting;
using System.Runtime.Remoting.Channels;
using System.Runtime.Remoting.Channels.Http;
using System.Runtime.Remoting.Channels.Tcp;

class RemotingHost {
  static void Main(string[] args) {
    RemotingConfiguration.ApplicationName = "WiseOwlMathService";

    ActivatedServiceTypeEntry ASTE =
       new ActivatedServiceTypeEntry(typeof(WiseOwl.Calculator));
    RemotingConfiguration.RegisterActivatedServiceType(ASTE

    ChannelServices.RegisterChannel(new HttpChannel(9000));
    ChannelServices.RegisterChannel(new TcpChannel(4242));
    Console.ReadLine();
  }
}
```

Client activation URLs

- Client activated objects do not need a unique URL for each object

```
ProtocolScheme://ComputerName:Port/PossibleApplicationName
```

  - PossibleApplicationName becomes virtual directory name when hosted in IIS
  - A TcpChannel requires the port number

Remoting clients

- A clients wants to use a remote object
  - Well-known objects exist at a URL
    - Client obtains proxy using **Activator.GetObject**
    - Client can also obtain proxy using **new**
  - Client activated object factory exists at a URL
    - Client requests factory to instantiate object and return a proxy to it using **Activator.CreateInstance**
    - Client can also make same request using **new**

Activator.GetObject

- GetObject returns a proxy for the well-known type served at the specified location

```
Dim o as Object = Activator.GetObject (
             GetType (WiseOwl.Calculator),
            "http://localhost:9000/WiseOwlMathService/SharedCalc")

WiseOwl.Calculator c = CType (o, WiseOwl.Calculator)

c.Add (42);
```

- No network traffic until first method call!
  - Proxy built on client from metadata
  - Server activates object on first method call

RemotingServices.Connect

- GetObject is a thin wrapper over System.Runtime.Remoting. RemotingServices.Connect

```
Using System.Runtime.Remoting;

static object o RemotingServices.Connect (
                                   Type classToProxy, string url);
```

  - Which calls System.Runtime.Remoting. RemotingServices.Unmarshal

RemotingServices.Unmarshal

- RemotingServices.Unmarshal does the real work
  - Checks that type is MarshalByRef or Interface
  - Find or creates identity based on URI
  - Creates envoy and channel sink chains
  - Gets or creates transparent and real proxy
- End results is client gets a proxy

How does it work?

- Client receives a proxy object when activating a remote object
  - Client "thinks" proxy is actual object
- Proxy is instance of **TransparentProxy** class
  - Mimics inheritance hierarchy of remote object
- A call on the proxy:
  - passes control to actual object when in same domain
  - creates an **IMessage** to object in different domain
  - Passes message to a **RealProxy** instance

RealProxy class

- **RealProxy** forwards msg to remote object
  - Handles all method calls to remote object
- RealProxy class can be extended, customized
  - For example, load balancing method calls, client side validation/processing of certain calls
- TransparentProxy cannot be replaced
  - Internal remoting implementation class

IsTransparentProxy

- You can call IsTransparentProxy on any object reference to see if it is a proxy
  - Normally, you don't care

```
using System.Runtime.Remoting;

bool RemotingServices.IsTransparentProxy (Object o);
```

ObjRef

- Runtime creates an ObjRef when you register an object with the remoting services
- An ObjRef contains all information required to locate and access a remote object
  - the strong name of the class
  - the class's hierarchy (its parents)
  - the names of all interfaces the class implements
  - the object URI
  - details of all available registered channels

How to remote existing objects

- Server/client activation expose "new" objects
  - What about existing objects?
- RemotingService.Marshal
  - Accepts a MarshalByRefObject
  - Registers it with remoting
  - Returns an ObjRef
- RemotingService.Unmarshal
  - Accepts an ObjRef
  - Returns a proxy

RemotingServices.Marshal

```
//
// On the server, we find our hero about to go public. . .
WiseOwl.Calculator calc = new WiseOwl.Calculator ();

// Let the remoting layer (and the world) know about it
ObjRef or = RemotingServices.Marshal (calc, "ExplicitCalculator");

// Clients can now connect to the Calculator as a Well-known object
// prot://machine:port/WiseOwlMathServices/ExplicitCalculator

// Alternatively, we can serialize and send the ObjRef to a client
//
System.Runtime.Serialization.Formatters.Soap.SoapFormatter sf =
            new System.Runtime.Serialization.Formatters.Soap.SoapFormatter ();
System.IO.FileStream fs =
            new System.IO.FileStream (@"C:\ObjRef.xml", System.IO.FileMode.Create);
sf.Serialize (fs, or);
fs.Close ();
```

RemotingServices.Unmarshal

```
'
' There's an ObjRef serialized to a file using the SOAP formatter
' Get a formatter that can read the format
Dim sf As System.Runtime.Serialization.Formatters.Soap.SoapFormatter
    sf = New System.Runtime.Serialization.Formatters.Soap.SoapFormatter()

' Open a stream on the file
Dim fs As System.IO.FileStream
    fs = New System.IO.FileStream("C:\ObjRef.xml", System.IO.FileMode.Open)

' Deserialize the object in the file
Dim o As Object = sf.Deserialize(fs)

fs.Close()          ' Done with the file

' Object is really an WiseOwl.Calculator
Dim c As WiseOwl.Calculator = CType(o, WiseOwl.Calculator)

' Use the Calculator
c.Add(21)
```

.NET Remoting

- .NET supports two basic forms of remoting
  - Web Services
    - An entry point into application specified by an URL
      - <protocol>:<machine>:<port>/<URI>
        E.g. http://localhost:4242/SomeServiceName
    - Uses SOAP data types
  - CLR Object Remoting
    - Builds on Web Services
    - Uses native CLR data types

Web Services

- Expose WebService endpoints from any process over any transport using any payload encoding
- Process types include console apps, graphical applications, NT Services, IIS
- Built-in Transports include HTTP and TCP
  - Extensible via pluggable channels
- Built-in encodings include SOAP and Binary
  - Extensible via pluggable serialization formatters
- Supports SOAP 1.1 (~XSD) type system

CLR Object Remoting

- Full CLR type system fidelity
  - class hierarchies, constructors, delegates, interfaces, methods, overloaded methods, properties, fields
- Supports additional features over Web Services
  - Marshal by value (make a copy)
  - Marshal by reference (pass an ObjRef)
- Maintains distributed object identity
- Provides object activation semantics
- Allows control over object lifetime using leases
- Permits out of band info using CallContext

Remoting via Web Services

- **Any** client ←→ .NET using HTTP/SOAP
  - .NET object exposed as a Web Service by hosting in IIS
  - Web Services use well-defined interfaces called contracts
    - ➔Contracts are described using a Web Services Description Language (WSDL) file
  - Any client that can consume a WSDL file can make SOAP calls to the remote object as per the contract
  - Firewall friendly, client OS agnostic
  - XML Schema data (XSD) types used in contract

Remoting via HTTP

- .NET client ←→ .NET using HTTP/SOAP
  - HTTP channel uses the SOAP formatter
    - Can override this default behavior
    - Less efficient than binary formatter
  - Firewall friendly
  - Uses CLR type system, not XSD

Remoting via TCP

- .NET client ←→ .NET using TCP channel
  - TCP channel uses the binary formatter
    - Can override this default behavior
    - More efficient than SOAP formatter
  - Raw socket connection used for transport
    - Mostly useful behind a firewall, not through one

Remoting via DCOM

- .NET client ←→ COM ←→ .NET
  - .NET client to COM uses RCW and COM interop
    - DCOM used when COM object is remote
  - COM to .NET uses CCW and COM interop
    - DCOM used when .NET server is remote
- Useful in heterogeneous environments

Using IIS as the host server

- IIS provides activation
  - Server does not have to be manually started
  - IIS uses web.config remoting config file

```
<configuration>
  <system.runtime.remoting>
    <application>
      <service>
        <wellknown mode="SingleCall"
                   type="WiseOwl.Calculator,MathObjects" objectUri = "EphemeralCalc.rem" />
        <wellknown mode="Singleton"
                   type="WiseOwl.Calculator,MathObjects" objectUri = "SharedCalc.soap" />
        <activated type = "WiseOwl.Calculator,MathObjects"/>
      </service>
    </application>
  </system.runtime.remoting>
</configuration>
```

server.cs

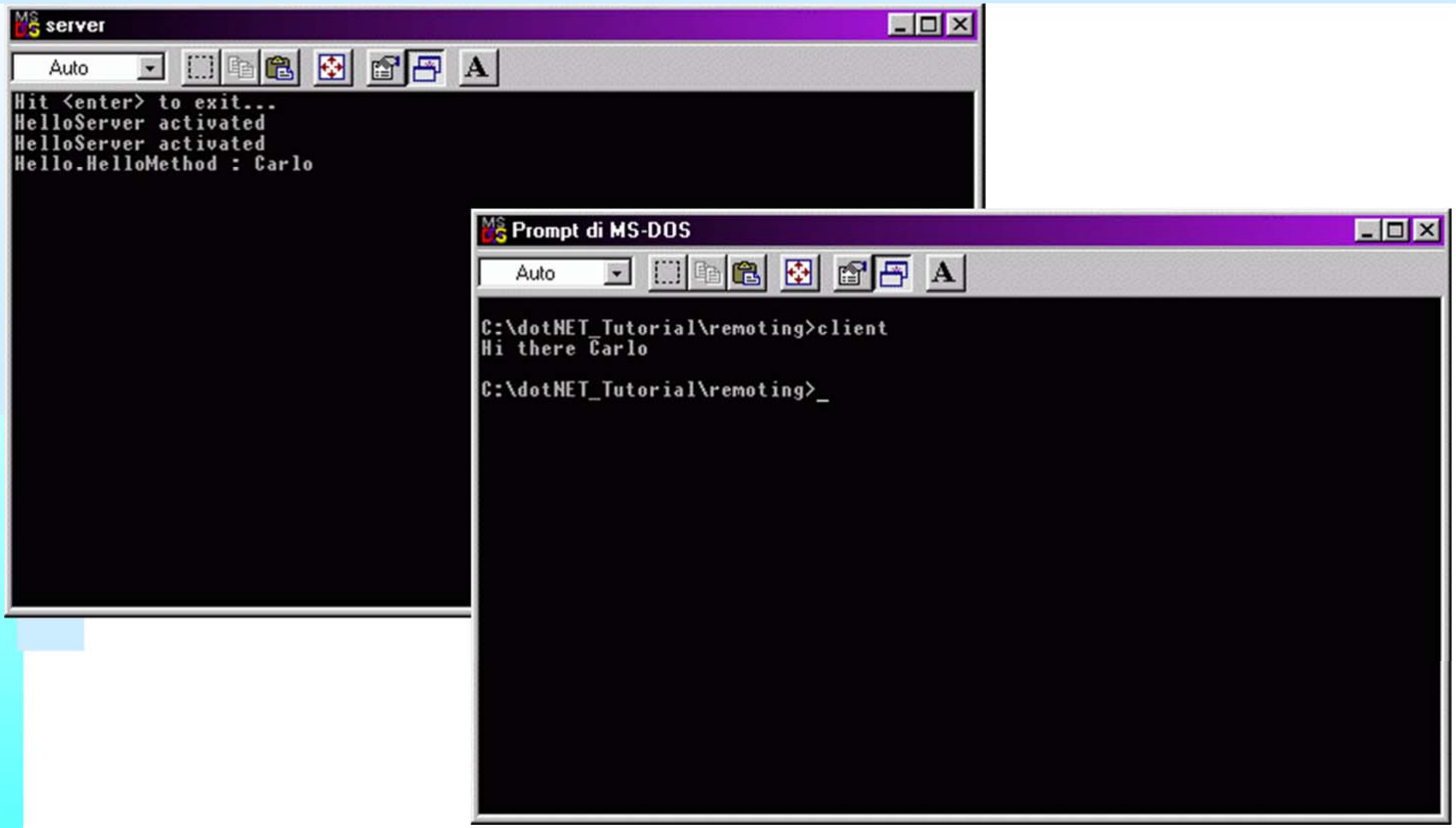
```
using System;
using System.Runtime.Remoting;
using System.Runtime.Remoting.Channels;
using System.Runtime.Remoting.Channels.Tcp;

namespace RemotingSamples {
  public class Sample {

    public static int Main(string [] args) {
      // Crea e registra un nuovo canale Tcp
      TcpChannel chan = new TcpChannel(8085);
      ChannelServices.RegisterChannel(chan);
      // Il metodo RegisterWellKnownServiceType permette di registrare l’oggetto per la
      // futura attivazione [PARAMETRI (Tipo, URI, metodo di attivazione)]
      RemotingConfiguration.RegisterWellKnownServiceType
      (Type.GetType("RemotingSamples.HelloServer,object"),
      "SayHello", WellKnownObjectMode.SingleCall);
      System.Console.WriteLine("Hit  to exit...");
      System.Console.ReadLine();
      return 0;
    }
  }
}
```

object.cs

```
using System;
using System.Runtime.Remoting;
using System.Runtime.Remoting.Channels;
using System.Runtime.Remoting.Channels.Tcp;

namespace RemotingSamples {
  public class HelloServer : MarshalByRefObject {

    public HelloServer() {
      Console.WriteLine("HelloServer activated");
    }

    public String HelloMethod(String name) {
      Console.WriteLine("Hello.HelloMethod : {0}", name);
      return "Hi there " + name;
    }
  }
}
```

client.cs

```
using System;
using System.Runtime.Remoting;
using System.Runtime.Remoting.Channels;
using System.Runtime.Remoting.Channels.Tcp;

namespace RemotingSamples {
  public class Client
  {
    public static int Main(string [] args)
    {
      TcpChannel chan = new TcpChannel();
      ChannelServices.RegisterChannel(chan);
      // Il client localizza l'oggetto remoto passando tipo e URL
      HelloServer obj =
   (HelloServer)Activator.GetObject(typeof(RemotingSamples.HelloServer)
   , "tcp://localhost:8085/SayHello");
      if (obj == null)
      System.Console.WriteLine("Could not locate server");
      else Console.WriteLine(obj.HelloMethod("Carlo"));
      return 0;
    }
  }
}
```



```
Hit <enter> to exit...
HelloServer activated
HelloServer activated
Hello.HelloMethod : Carlo
```

```
C:\dotNET_Tutorial\remoting>client
Hi there Carlo

C:\dotNET_Tutorial\remoting>_
```

References

- http://www.dotnetremoting.cc
- http://www.c-sharpcorner.com/Remoting.asp