Code-N-Play:

Deployable Protocol Stacks

PouzinSociety@FutureNet 2010

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Agenda

- Background
  - TSSG / WIT
  - EU FP7 –ICT 4WARD
- The Fun Stuff
  - Prelude
  - Fetching the pieces
  - Network Medium
- Roadmap
  - Today
  - Tomorrow
- Demo / Backup Slides

Background

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TSSG

- The Telecommunications Software & Systems Group (TSSG) is one of the largest integrated information communication technology (ICT) research centres in Ireland.
- TSSG is part of Waterford Institute of Technology (WIT), and is based at WIT's West Campus in Carriganore, Co. Waterford, Ireland.
- More Information:
  - http://www.wit.ie
  - http://www.tssg.org

Waterford Institute *of* Technology

TSSG

TSSG - Balanced Ecosystem

TSSG:

- Basic Research (HEA, SFI)

✓ One of the top research centers in Ireland (telecommunications)

- Applied Research (EU FP7)

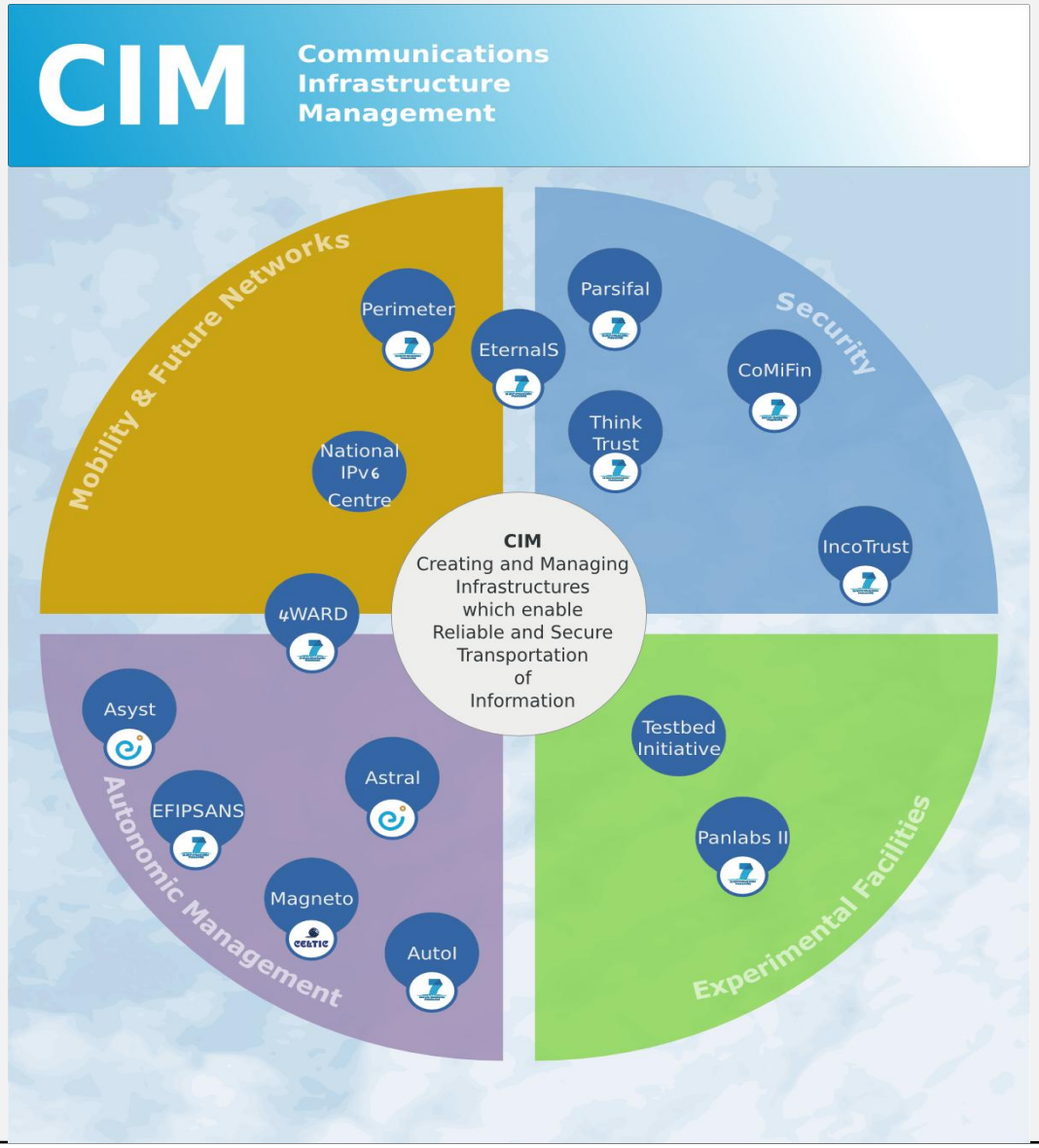
✓ Leading Irish participant in EU FP7 funding – 11 projects

✓ Ranked in top 10 research institutes for Future Internet

TSSG:

- Commercialization (EI)
  - ✓ One of the top research groups for commercialization
  - ✓ Leading edge innovation & technology development in: IMS, Web 2.0 Mobile
- Commercial 'Spin-offs' / 'Spin-ins'
  - ✓ Early stage technology clusters emerging based around TSSG work

TSSG: Where I work ☺



4WARD [IP EU FP7 ICT]

- The 4WARD project is looking to the new architecture and design of the Future Internet and has set itself the task of creating a new approach to networking architecture that is more flexible and better adapted to present and future requirements.
- Co-Ordinator : Ericsson
  - 37 Partners including Nokia, Alcatel-Lucent, NEC, Telefonica, Deutsche Telekom, France Telecom, Telecom Italia…
- More Information
  - **http://www.4ward-project.eu**

Finally the interesting stuff…

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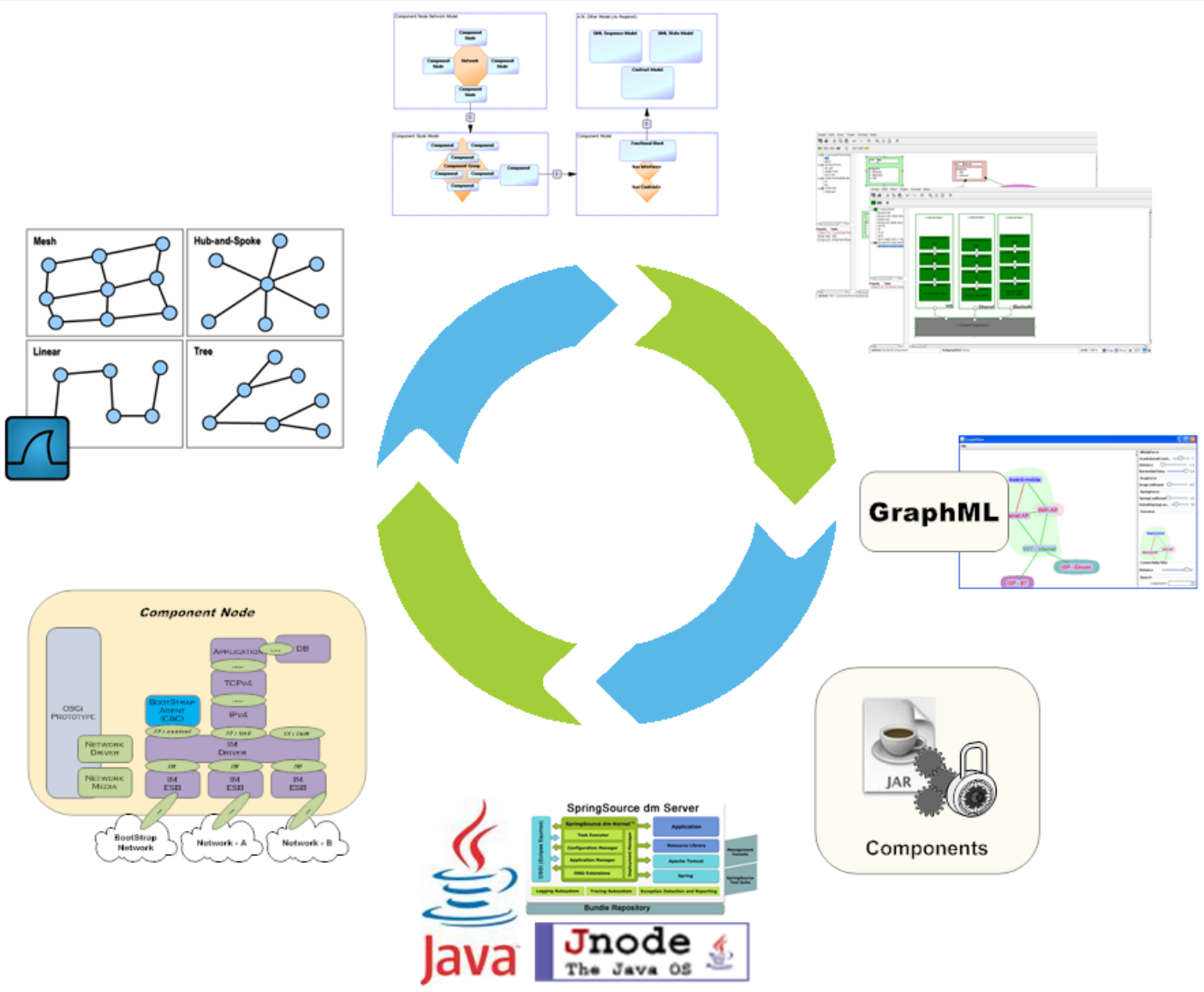
Prelude: Timeline from the beginning…



Prelude: Guiding Principles

- KISS Principle
  - Light weight, Modular, Flexible, Best Practises
  - Agility + Flexibility + Ease-Of-Use = Productivity
  - Java (Popular, low barrier to entry)
  - OSGi (Industry Standard)

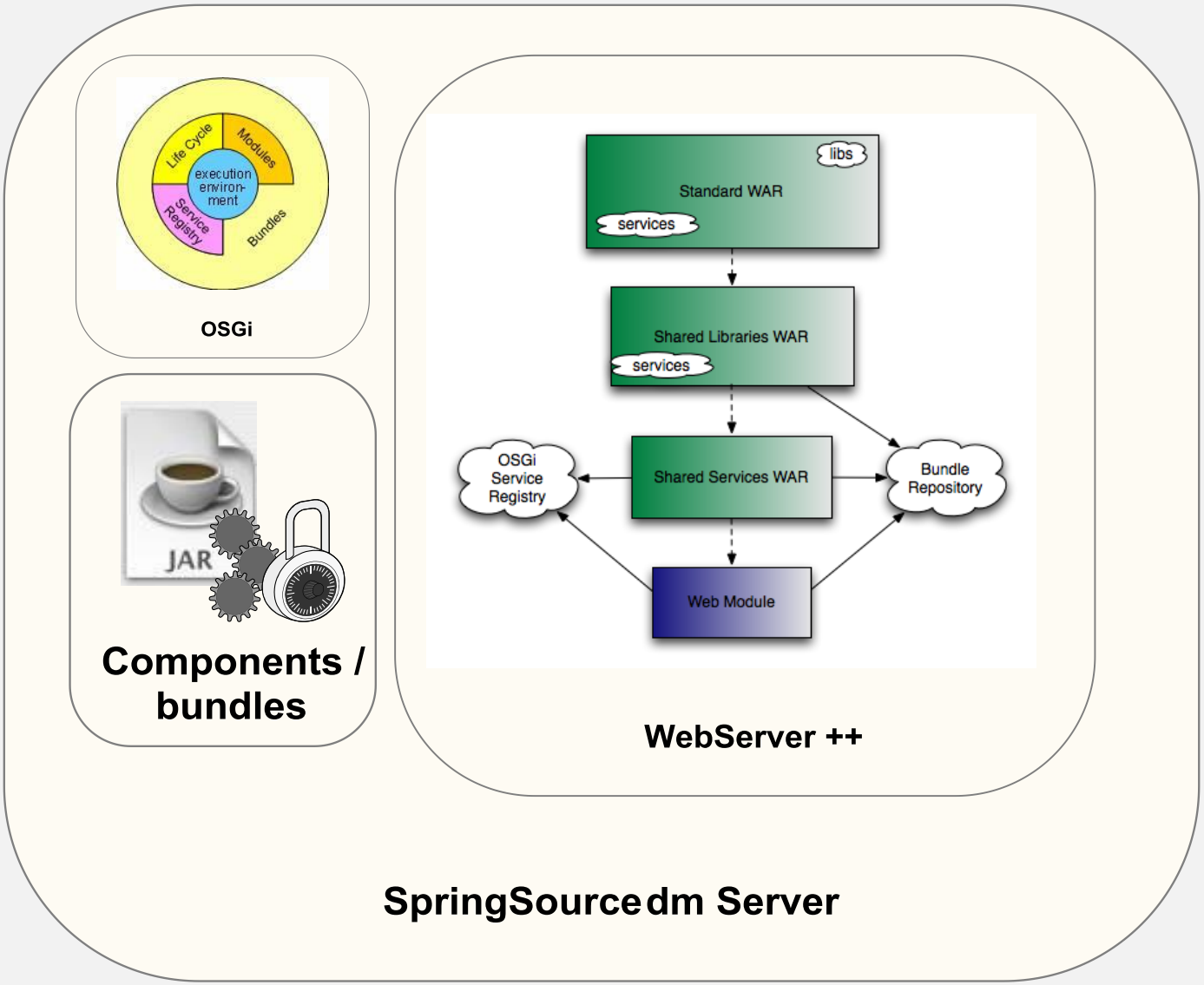
- Software Development Practices
  - Convention, Configuration, Code
    - In that order for higher productivity
  - Service based through & through
    - Looser coupling, easier maintenance
  - Grows with the Scenarios
    - Pick-and-choose only the features required

Executive Summary: In a nutshell

- Java based development, deployment and execution
  - No C/C++, No OS Kernel (User space), No pain
  - Removal of barrier to entry
  - Cross platform – OS independent.
  - Off the shelf (free/community tools / platform)
  - Applying Industry practises / tooling
- Design – Develop – Deploy
- *Its Software - Nothing is impossible!*

- ***Network Protocol(s) / Stack implementation / testing***
- ***Network & Node configuration & deployment***
- ***Complete Programmatic Control – Repeat Scenarios***

Fetching Pieces: SpringSource dm Server



Fetching Pieces: SpringSource dm Server

- **SpringSource dm Server™** is a completely modular, OSGi-based Java server designed to run enterprise Java applications and Spring-powered applications with a new degree of flexibility and reliability. The SpringSource dm Server is based on the new SpringSource Dynamic Module Kernel™ (dm Kernel).
  - http://www.springsource.org/dmserver
- **OSGi™ - The Dynamic Module System for Java™**
  - http://www.osgi.org/Main/HomePage
- **SpringSource dm Server™ moves to Eclipse**
  - **Project Virgo (EPL Licensing)**

Fetching Pieces: Network Stack (Jnode)

Java HTTP Implementation

Java TCP Implementation

Java IP Implementation

Java ARP/RARP Implementation

Fetching Pieces: Network Stack (Jnode)

- **JNode** (Java New Operating System Design Effort) is an open-source project to create a Java platform operating system. The project has taken the unique direction of creating all the software in Java itself, with the exception of some assembly language to boot and load the system.
  - http://www.jnode.org

- Extracted/Componentised the Network Sub-System of the Operating System.
  - Protocols, Device & Network Infrastructure.

Fetching Pieces: Transport (XMPP)

- XMPP – http://www.xmpp.org
  - Open Standards – RFC 3920, 3921
  - Underlying protocol for most IM applications.
    - Jabber, Google Talk…
  - Widespread use, various implementations.
  - Open Source Clients / Servers / Libraries.
    - Ignite Realtime – Openfire (Server) / Smack (Client Library)
    - http://www.igniterealtime.org/projects/openfire/
  - Interesting side effect : XMPP is a reliable transport.
    - *Programmatic control of "unreliability"*
    - *Reproducible failure / congestion scenarios.*

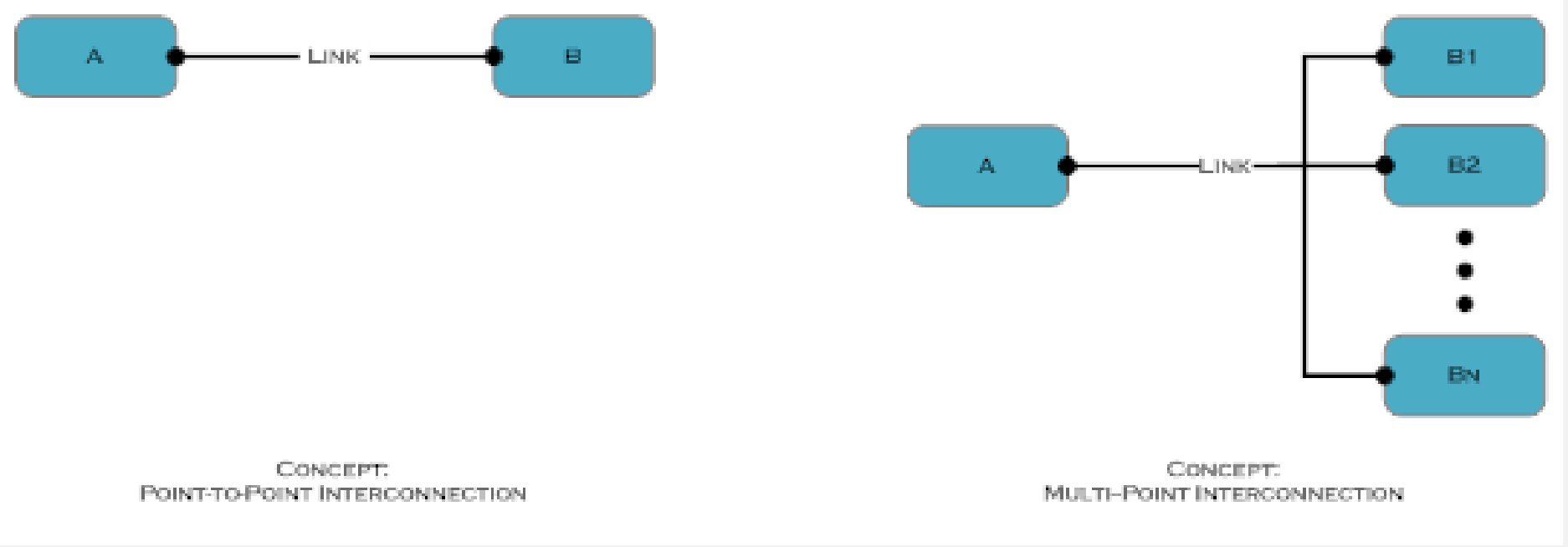
Assembly: From Models to Implementation

- OSGi - bundles are components.
- OSGi - network protocols are exposed as OSGi services
- OSGi - “network stack” is SOA assembled
- OSGi – “Application” is a component node
- dm Server - “Application”(s) isolated from each other
- dm Server – Deployment platform.
- The underlying network medium is XMPP – virtual network (overlay).
  - XMPP is the current flavour of overlay.
  - Abstracted at the driver interface – can be implemented over “sockets” or magic pixie dust if required.

Network Medium

Network Medium: Concepts

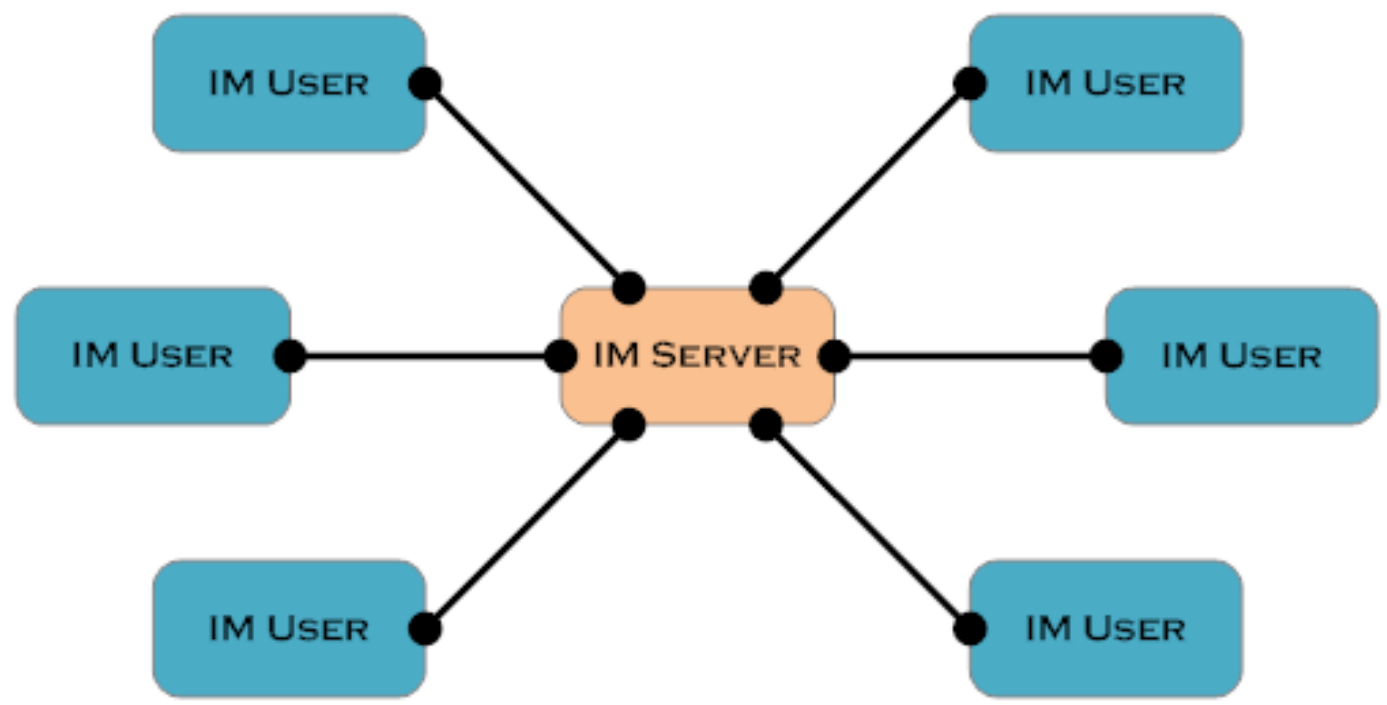
Point-to-Point / Multi-Point



Note:

In terms of hardware all network connectivity is either point-to-point or multi-point.

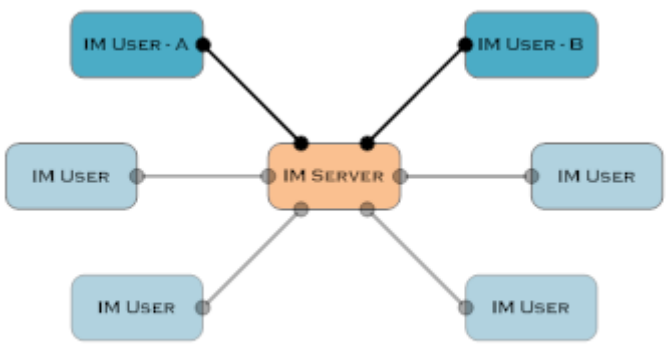
Network Medium: XMPP

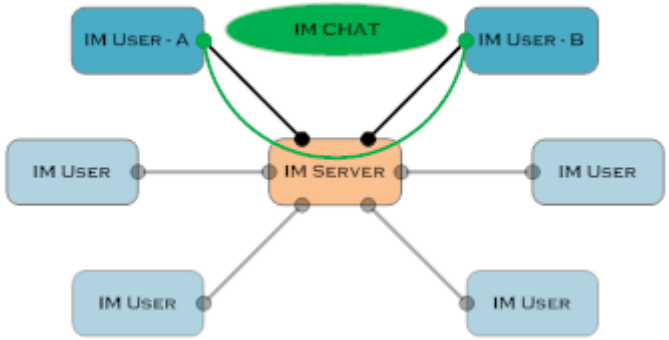


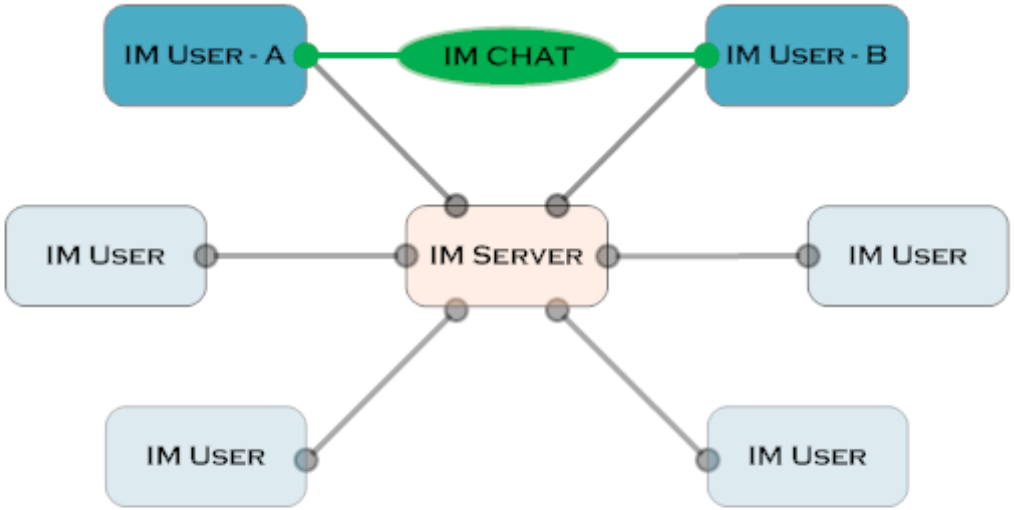
Underlying IM Network
(Composed of Point-To-Point Interconnections)

Protocol : XMPP protocol, sits on top of TCP/IP

Network Medium: Point-to-Point



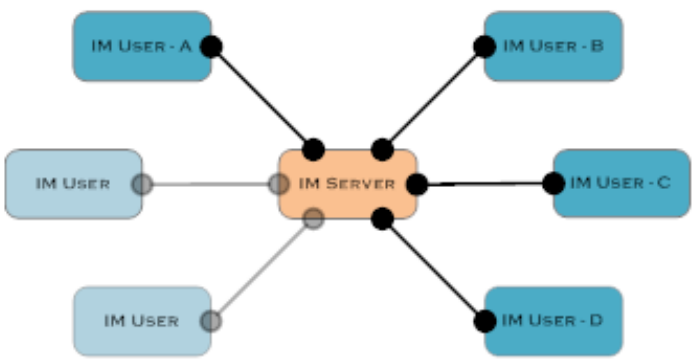


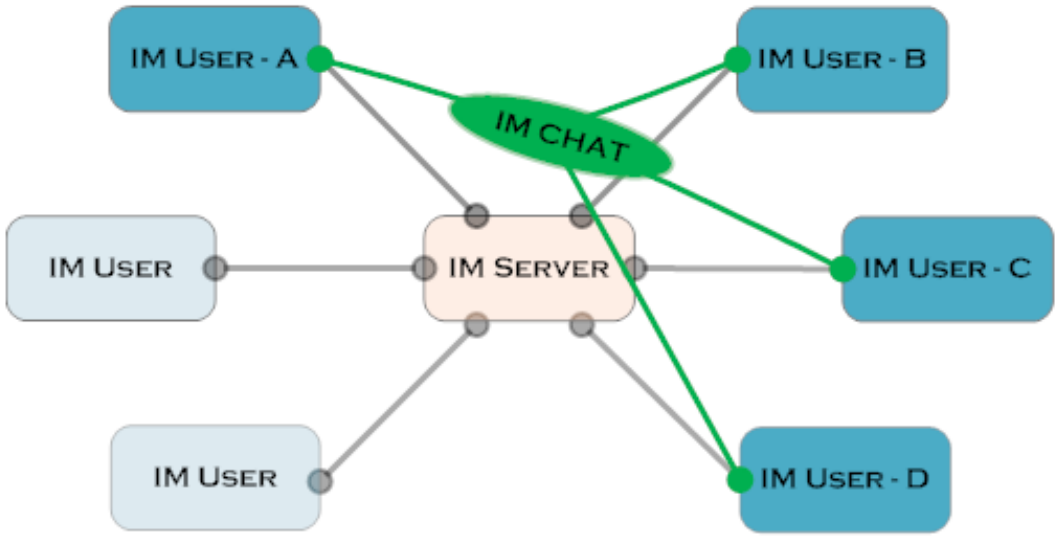


SIMPLE A-B COMMUNICATION DEMONSTRATES THE POINT - TO - POINT INTERCONNECTION CONCEPT.

CHATROOM WITH 2 MEMBERS

Network Medium: Multi-Point

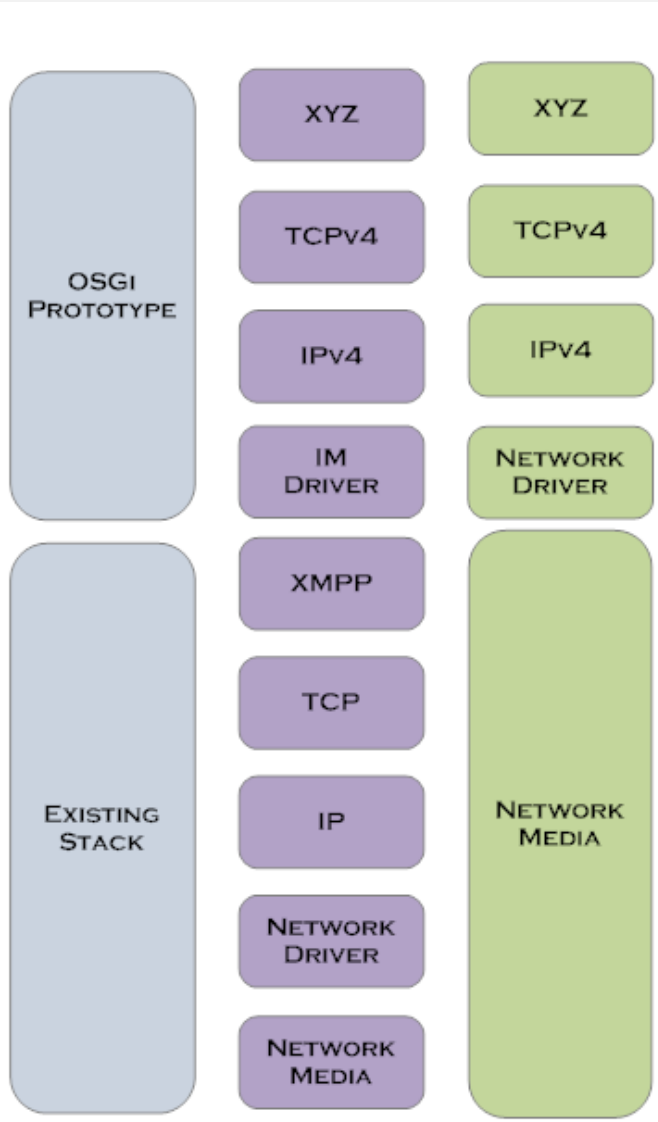


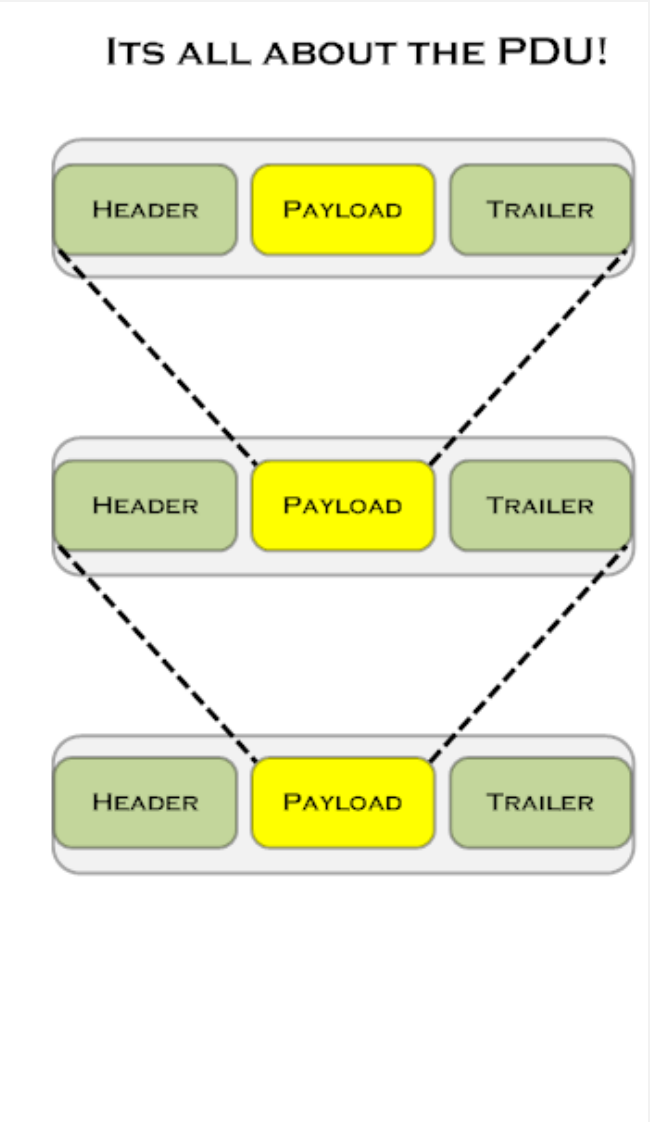


Simple A-B-C-D communication demonstrates the Multi-Point Interconnection concept.

Chatroom with 2+ members

Network Medium: Its All About The PDU





The payload of one layer is encapsulated with either a header/trailer of the current layer and becomes the payload of the N-1 layer.

This facilitates the encapsulation of our TCP/IP stack through XMPP and the existing TCP/IP stack unharmed.

Network Medium: Details

- A chat room represents a *hardware* network.
- A IM buddy represents a *hardware* Point-of-Attachment (POA) for our nodes.
- A node with multiple POAs can be a member of multiple networks i.e. can be a router.
- Any message sent by a node on the network can be seen by any other node with a POA to that network.

Network Medium: Sample PDUs

1

```
<XML>
<PDU>[...Protocol Data Unit...]</PDU>
</XML>
```

2

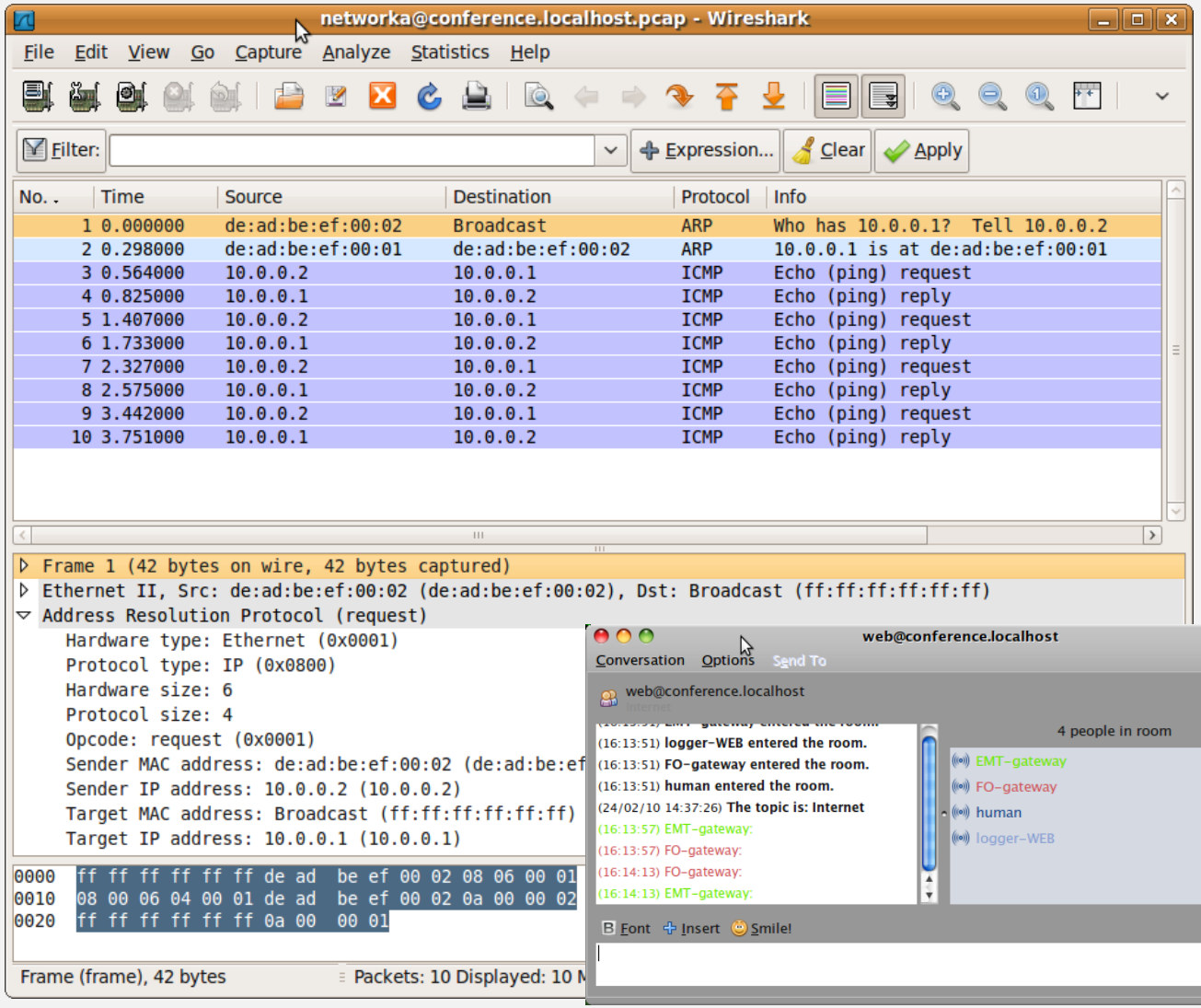
```
<XML>
<PDU>[...Protocol Data Unit...]</PDU>
<HOPS>
  <HOP>
   <SRC>IM-A</SRC>
   <NETWORK>Room-A</NETWORK>
   <DOMAIN>TELEFONICA</DOMAIN>
   <METRICS>
     <TIME-COST>1</TIME-COST>
     <EURO-COST>2</EURO-COST>
     <BANDWITH>3</BANDWIDTH>
   <METRICS>
 </HOP>
</HOPS>
</XML>
```

3

```
<XML>
<PDU>[...Protocol Data Unit...]</PDU>
<HOPLIST>
  <HOP>
    <SRC>IM-A</SRC>
    <NETWORK>Room-A</NETWORK>
    <DOMAIN>TELEFONICA</DOMAIN>
    <METRICS>
      <TIME-COST>1</TIME-COST>
      <EURO-COST>2</EURO-COST>
      <BANDWITH>3</BANDWIDTH>
    <METRICS>
  </HOP>
  <HOP>
    <SRC>IM-D</SRC>
    <NETWORK>Room-B</NETWORK>
    <DOMAIN>BT</DOMAIN>
    <METRICS>
      <TIME-COST>2</TIME-COST>
      <EURO-COST>0</EURO-COST>
      <BANDWITH>8</BANDWIDTH>
    <METRICS>
  </HOP>
</HOPLIST>
</XML>
```

Note: *As there is full control of the network medium, we can add as much/little additional data as required to PDU.*

Network Medium: Trace (PCAP)



Note: *Off the shelf tooling / GUIs where possible.*

Roadmap

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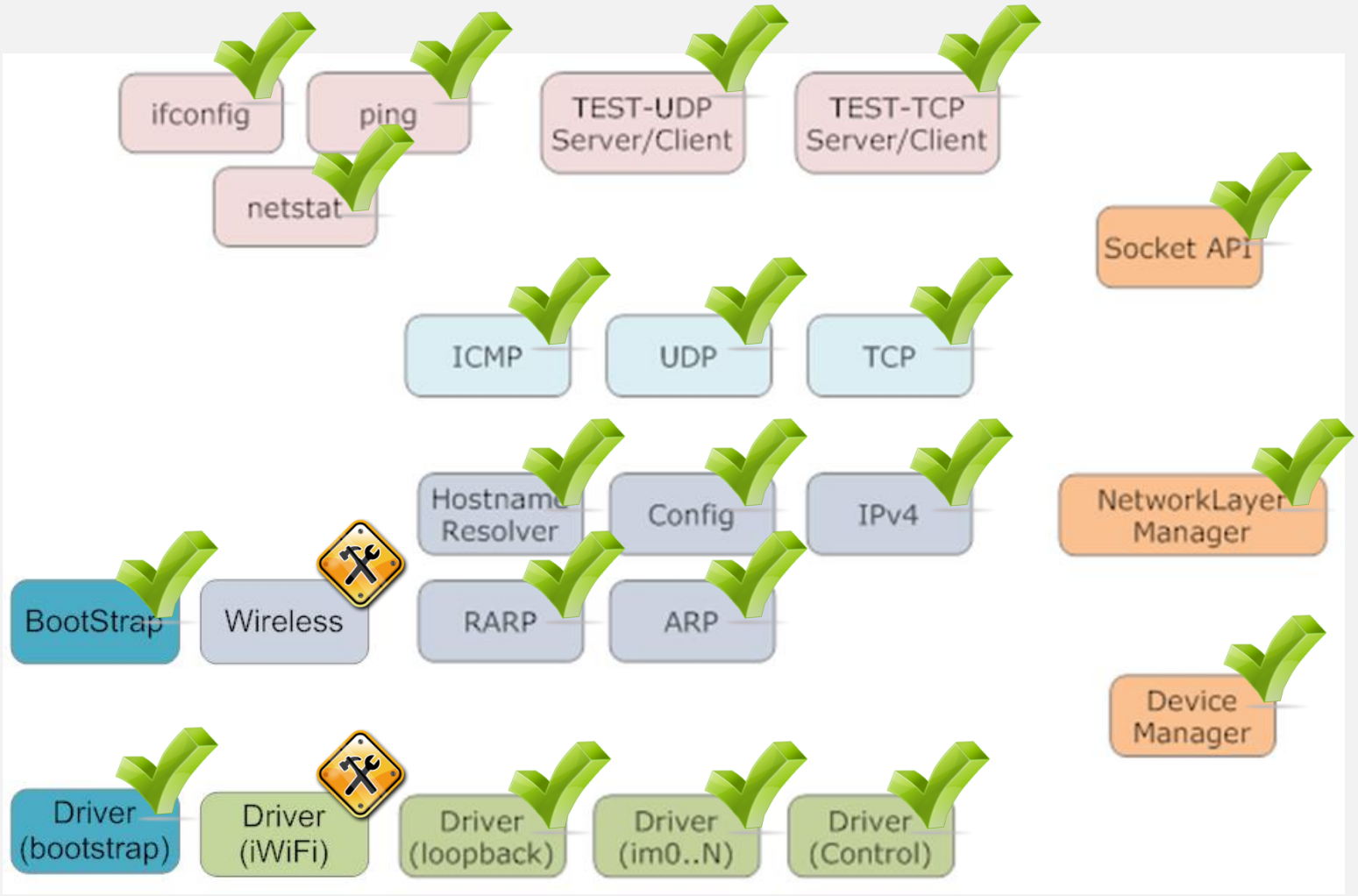
Today: Toolbox

- Documentation
  - Developer Build System / Install Guides
  - Various free resources (internet)
- Tools / Frameworks
  - Eclipse (with additional plugins)
  - SpringSource dm Server
  - Java 6
- Up and Running quickly with templates
  - Spring OSGi PLAN Template
  - Spring OSGi Bundle Template (similar to a JAR)
  - Templated examples – starting points

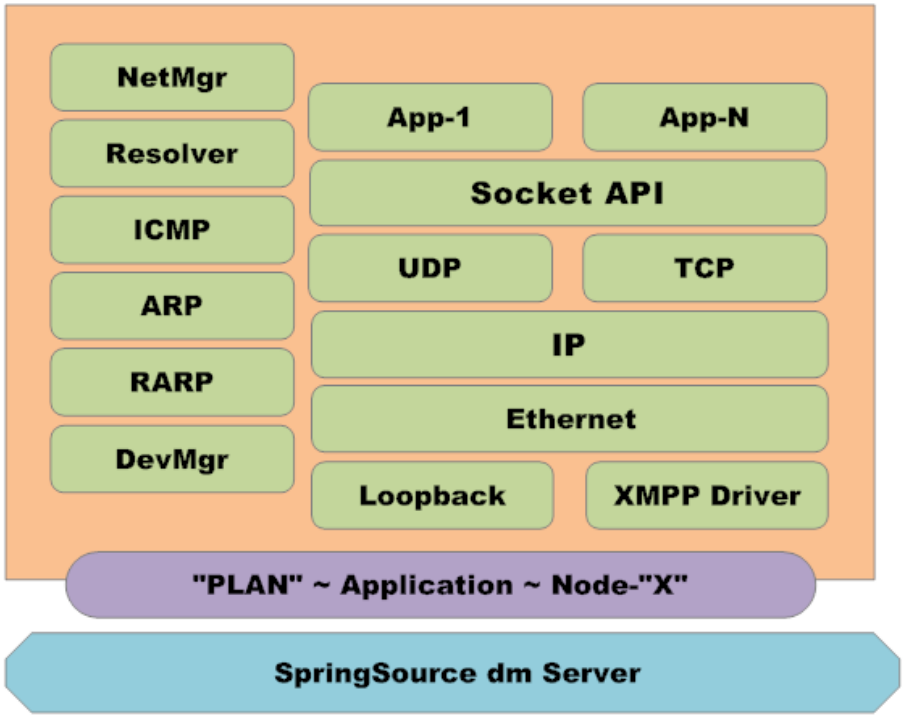
Today: Status (Pictures are pretty)



Today: Status

- IPv4 Based Network Stack (verified operational)
  - Faux Socket API
  - TCP / UDP / ICMP/ IP/ ARP/ RARP
  - Loopback Driver / Ethernet Driver
  - Device Manager / NetworkLayer Manager / Name Service
  - Dynamic Stack Configuration (IP addresses/ Routes/ Interfaces / Hostname Resolution)
  - Multi-Threaded Operation
    - Bundles, Threadpools (send, packet processor, etc.), logging
  - Service Orientated Interaction (Protocols)
  - Logging – PCAP format traces from networks.

Today: Node Deployment




```
-<plan name="org.tssg.ndr-gateway.plan" version="1.0.0" scoped="true" atomic="true"
 xsi:schemaLocation="http://www.springsource.org/schema/dm-server/plan
 http://www.springsource.org/schema/dm-server/plan/springsource-dm-server-plan.xsd">
   <!-- BootStrap -->
   <artifact type="bundle" name="org.tssg.bootstrap.api" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.bootstrap.driver" version="[1, 2)"/>
  -<artifact type="bundle" name="org.tssg.bootstrap.strata.agent" version="[1, 2)">
     <property name="header:org-tssg-bootstrap-hint" value="NDR-gateway"/>
   </artifact>
   <!-- Transport -->
   <artifact type="bundle" name="org.tssg.transport.im" version="[1, 2)"/>
   <!-- Configuration -->
   <artifact type="bundle" name="org.tssg.config.dao" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.config.stack" version="[1, 2)"/>
   <!-- JNode -->
   <artifact type="bundle" name="org.tssg.org.jnode.net.support" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.ethernet" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.driver.net.loopback" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.arp" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.ipv4" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.ipv4.layer" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.ipv4.icmp" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.ipv4.config" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.ipv4.tcp" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.ipv4.udp" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.org.jnode.net.ipv4.resolver" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.jnode.net" version="[1, 2)"/>
   <!-- TSSG Support -->
   <artifact type="bundle" name="org.tssg.support.jnode" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.driver.net.idrive" version="[1, 2)"/>
   <!-- Partner Support -->
   <artifact type="bundle" name="org.tssg.config.partner.dao" version="[1, 2)"/>
   <artifact type="bundle" name="org.tssg.config.partner.bootstrap" version="[1, 2)"/>
  -<artifact type="bundle" name="org.tssg.web.node" version="[1, 2)">
     <property name="header:Web-ContextPath" value="ndr"/>
   </artifact>
```

- Node deployment via “Plan” file.
  - XML blueprint for “application” or nodes.
  - !Full Circle! – From models to deployment plans ☺

Today: Node WebGUI

Machine

Hardware Interfaces

Interface	MAC-Address	MTU-Size
im1	DE:AD:BE:EF:00:02	1500
im0	DE:AD:BE:EF:00:01	1500
bootstrap	BA:D0:00:00:BA:BE	0
loopback	00:00:00:00:00:00	1500

Strata Medium

Domain	NodeId	Interface	Multicast Address	Multicast Port
FO	FO-gateway	<<	Home Domain	>>
External	FO-gateway	im0	225.1.0.3	3000
FO	FO-gateway	im1	225.1.1.3	3010

Connection Endpoints

Interface	IP-Address	Netmask
im1	10.0.1.1	255.255.255.0
im0	10.0.0.1	255.255.255.0
bootstrap	NotConfigured	NotConfigured
loopback	127.0.0.1	255.255.255.255

Connection Routing

Device	Destination	SubNetMask	Gateway	Flags	UseCount
loopback	127.0.0.1	0.0.0.0	127.0.0.1	UGH	0
im0	10.0.0.0	255.255.255.0		U	0
im1	10.0.1.0	255.255.255.0		U	0

SLA Management

Registered SLA Domains

Domain	Node	IP Address
EMT	EMT-gateway	10.0.0.2

Enforced SLAs

Domain	SLA Id	RemoteDomain	Metric	Threshold	Threshold
NegotiatedSLA	team1	EMT	delay	70	85

My Domain

Node	IP Address
FO-gateway	/10.0.1.1

Discovered Domains

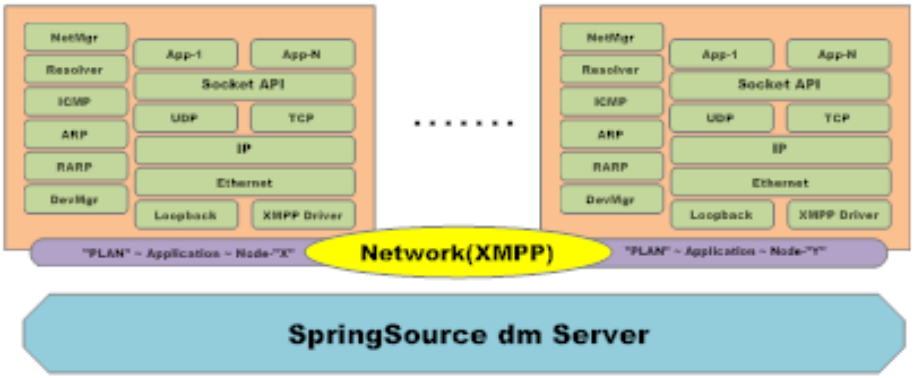
Domain	Node	IP Address
EMT	EMT-gateway	10.0.0.2

Governance

Congestion Level

INM Module	Percentage
Domain Congestion(GAP)	32

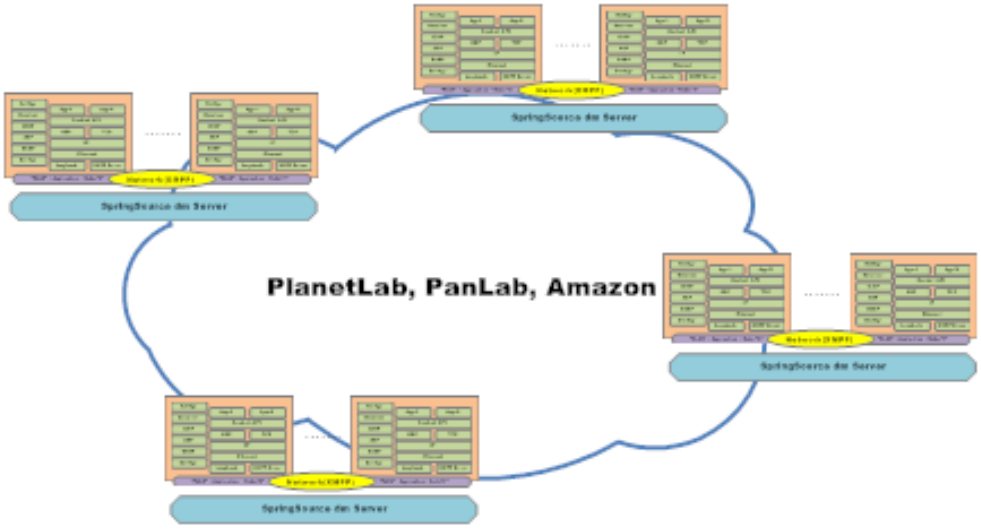
Today & tomorrow: Networks of Nodes



- Topologies are configured using the XMPP chat room(s) and the Node connections to them.

- Currently deploying nodes within dm Server(s) across physical machines.

- In the Future – Cloud Deployment



Tomorrow: TODO List

- Wireless Support
  - Allow prototyping of network protocols
  - Allows roaming/mobility scenarios
- Add "Slices" support to our component bundles
  - Allow easier / better 3rd party integration
  - Increased flexibility for deployments
- Cloud Deployment
  - Provide PlanetLab / PanLab / Amazon integration
  - Large scale experiments
  - *Sometimes a low end laptop might not be enough: 4WARD Review Demo - 5 nodes, 4 networks, 3 management domains*

Tomorrow: TODO List

- TINOS (Going Open Source)
  - Currently within the 4WARD IPR Process
  - Currently LGPL for all components
  - What's in a name: TINOS
    - A small island off the coast of Greece.
    - Who knew – picking a project name was so difficult.
  - Building a community
    - *Remove the barrier to entry to Network Protocols/Stacks*
    - Educate, Educate, Educate
    - Developers, Developers, Developers

Tomorrow: TODO List

- Pouzin Society (RINA)
  - Open Implementation of RINA within TINOS
  - Experimental Sandbox / Testbed (within a laptop)
  - Pre-Canned RINA Demos / Scenarios

Contribute

Help us build it

Demo Shots / Backup Slides

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Demo Shots: OSGi Console (2 Nodes)

```
81      ACTIVE      app.node.self.configure-1-app.node.self.configure-synthetic.context_1.0.0
82      ACTIVE      app.node.self.configure-1-org.tssg.bootstrap.agent_1.0.0
83      ACTIVE      app.node.self.configure-1-org.tssg.bootstrap.api_1.0.0
84      ACTIVE      app.node.self.configure-1-org.tssg.bootstrap.driver_1.0.0
85      ACTIVE      app.node.self.configure-1-org.tssg.config.dao_1.0.0
86      ACTIVE      app.node.self.configure-1-org.tssg.config.stack_1.0.0
87      ACTIVE      app.node.self.configure-1-org.tssg.driver.net.idrive_1.0.0
88      ACTIVE      app.node.self.configure-1-org.tssg.network.stack_1.0.0
89      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.driver.net.loopback_1.0.0
90      ACTIVE      app.node.self.configure-1-org.tssg.jnode.net_1.0.0
91      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.arp_1.0.0
92      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.ethernet_1.0.0
93      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.ipv4_1.0.0
94      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.ipv4.config_1.0.0
95      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.ipv4.icmp_1.0.0
96      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.ipv4.layer_1.0.0
97      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.ipv4.resolver_1.0.0
98      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.ipv4.tcp_1.0.0
99      ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.ipv4.udp_1.0.0
100     ACTIVE      app.node.self.configure-1-org.tssg.org.jnode.net.support_1.0.0
101     ACTIVE      app.node.self.configure-1-org.tssg.support.jnode_1.0.0
102     ACTIVE      app.node.self.configure-1-org.tssg.transport.im_1.0.0
103     ACTIVE      app.node.self.configure.instance2-1-app.node.self.configure.instance2-
synthetic.context_1.0.0
104     ACTIVE      app.node.self.configure.instance2-1-org.tssg.actions.ping_1.0.0
105     ACTIVE      app.node.self.configure.instance2-1-org.tssg.bootstrap.agent_1.0.0
106     ACTIVE      app.node.self.configure.instance2-1-org.tssg.bootstrap.api_1.0.0
107     ACTIVE      app.node.self.configure.instance2-1-org.tssg.bootstrap.driver_1.0.0
108     ACTIVE      app.node.self.configure.instance2-1-org.tssg.config.dao_1.0.0
109     ACTIVE      app.node.self.configure.instance2-1-org.tssg.config.stack_1.0.0
110     ACTIVE      app.node.self.configure.instance2-1-org.tssg.driver.net.idrive_1.0.0
111     ACTIVE      app.node.self.configure.instance2-1-org.tssg.network.stack_1.0.0
112     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.driver.net.loopback_1.0.0
113     ACTIVE      app.node.self.configure.instance2-1-org.tssg.jnode.net_1.0.0
114     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.arp_1.0.0
115     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ethernet_1.0.0
116     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4_1.0.0
117     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.config_1.0.0
118     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.icmp_1.0.0
119     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.layer_1.0.0
120     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.resolver_1.0.0
121     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.tcp_1.0.0
122     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.udp_1.0.0
123     ACTIVE      app.node.self.configure.instance2-1-org.tssg.org.jnode.net.support_1.0.0
124     ACTIVE      app.node.self.configure.instance2-1-org.tssg.support.jnode_1.0.0
125     ACTIVE      app.node.self.configure.instance2-1-org.tssg.transport.im_1.0.0

osgi>
```

Demo Shots: Bundles (IPv4)

```
osgi> bundle 119
file:////home/deploy/development/springsource-dm-server-1.0.2.RELEASE/work/com.springsource.server.deployer/
Module/app.node.self.configure.instance2-1/org.tssg.org.jnode.net.ipv4.layer-1.0.0.jar [119]
  Id=119, Status=ACTIVE      Data Root=/home/deploy/development/springsource-dm-server-
1.0.2.RELEASE/work/equinox-config/org.eclipse.osgi/bundles/119/data
  Registered Services
    {org.jnode.net.NetworkLayer,
org.jnode.net.ipv4.IPv4Service}={org.springframework.osgi.bean.name=ipv4NetworkLayerBean, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.layer, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=175}
    {org.springframework.osgi.context.DelegatedExecutionOsgiBundleApplicationContext,
org.springframework.osgi.context.ConfigurableOsgiBundleApplicationContext,
org.springframework.context.ConfigurableApplicationContext, org.springframework.context.ApplicationContext,
org.springframework.context.Lifecycle, org.springframework.beans.factory.ListableBeanFactory,
org.springframework.beans.factory.HierarchicalBeanFactory, org.springframework.context.MessageSource,
org.springframework.context.ApplicationEventPublisher, org.springframework.beans.factory.BeanFactory,
org.springframework.core.io.ResourceLoader,
org.springframework.beans.factory.DisposableBean}={org.springframework.context.service.name=app.node.self.co
nfigure.instance2-1-org.tssg.org.jnode.net.ipv4.layer, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.layer, Bundle-Version=1.0.0,
service.id=176}
  Services in use:
    {org.jnode.net.Resolver}={org.springframework.osgi.bean.name=hostFileResolverBean, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.resolver, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=173}
    {org.jnode.net.NetworkLayer,
org.jnode.net.arp.ARPService}={org.springframework.osgi.bean.name=arpNetworkLayerBean, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.arp, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=168}
    {org.xml.sax.EntityResolver}={service.id=32}
    {org.springframework.beans.factory.xml.NamespaceHandlerResolver}={service.id=31}
  Exported packages
    org.jnode.net.ipv4.layer; version="1.0.0"[exported]
```

Demo Shots: Bundles (TCP)

```
osgi> bundle 121
file:////home/deploy/development/springsource-dm-server-1.0.2.RELEASE/work/com.springsource.server.deployer/
Module/app.node.self.configure.instance2-1/org.tssg.org.jnode.net.ipv4.tcp-1.0.0.jar [121]
  Id=121, Status=ACTIVE      Data Root=/home/deploy/development/springsource-dm-server-
1.0.2.RELEASE/work/equinox-config/org.eclipse.osgi/bundles/121/data
  Registered Services
    {org.jnode.net.TransportLayer,
org.jnode.net.ipv4.IPv4Protocol}={org.springframework.osgi.bean.name=IPV4_TCP_Protocol, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.tcp, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=180}
    {org.springframework.osgi.context.DelegatedExecutionOsgiBundleApplicationContext,
org.springframework.osgi.context.ConfigurableOsgiBundleApplicationContext,
org.springframework.context.ConfigurableApplicationContext, org.springframework.context.ApplicationContext,
org.springframework.context.Lifecycle, org.springframework.beans.factory.ListableBeanFactory,
org.springframework.beans.factory.HierarchicalBeanFactory, org.springframework.context.MessageSource,
org.springframework.context.ApplicationEventPublisher, org.springframework.beans.factory.BeanFactory,
org.springframework.core.io.ResourceLoader,
org.springframework.beans.factory.DisposableBean}={org.springframework.context.service.name=app.node.self.co
nfigure.instance2-1-org.tssg.org.jnode.net.ipv4.tcp, Bundle-SymbolicName=app.node.self.configure.instance2-
1-org.tssg.org.jnode.net.ipv4.tcp, Bundle-Version=1.0.0, service.id=181}
  Services in use:
    {org.jnode.net.NetworkLayer,
org.jnode.net.ipv4.IPv4Service}={org.springframework.osgi.bean.name=ipv4NetworkLayerBean, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.layer, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=175}
    {org.xml.sax.EntityResolver}={service.id=32}
    {org.springframework.beans.factory.xml.NamespaceHandlerResolver}={service.id=31}
  Exported packages
    org.jnode.net.ipv4.tcp; version="1.0.0"[exported]
```

Demo Shots: Bundles (Support)

```
osgi> bundle 124
file:////home/deploy/development/springsource-dm-server-1.0.2.RELEASE/work/com.springsource.server.deployer/
Module/app.node.self.configure.instance2-1/org.tssg.support.jnode-1.0.0.jar [124]
  Id=124, Status=ACTIVE      Data Root=/home/deploy/development/springsource-dm-server-
1.0.2.RELEASE/work/equinox-config/org.eclipse.osgi/bundles/124/data
  Registered Services
    {org.jnode.net.NetworkLayerManager}={org.springframework.osgi.bean.name=tssgNetworkLayerManagerBean,
Bundle-SymbolicName=app.node.self.configure.instance2-1-org.tssg.support.jnode, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=185}
    {org.jnode.driver.DeviceManager}={org.springframework.osgi.bean.name=tssgDeviceManagerBean, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.support.jnode, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=186}
    {org.springframework.osgi.context.DelegatedExecutionOsgiBundleApplicationContext,
                        :
                        :
-org.tssg.support.jnode, Bundle-Version=1.0.0, service.id=191}
  Services in use:
    {org.jnode.net.NetworkLayer,
org.jnode.net.ipv4.IPv4Service}={org.springframework.osgi.bean.name=ipv4NetworkLayerBean, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.ipv4.layer, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=175}
    {org.jnode.driver.DeviceFinder}={org.springframework.osgi.bean.name=loopbackDeviceFinder, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.driver.net.loopback, Bundle-
Version=1.0.0, com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=166}
    {org.jnode.net.NetworkLayer,
org.jnode.net.arp.ARPService}={org.springframework.osgi.bean.name=arpNetworkLayerBean, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.arp, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=168}
    {org.jnode.driver.DeviceFinder}={org.springframework.osgi.bean.name=imDeviceFinder, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.driver.net.idrive, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=163}
    {org.jnode.net.NetworkLayer}={org.springframework.osgi.bean.name=rarpNetworkLayerBean, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.org.jnode.net.arp, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=169}
    {org.xml.sax.EntityResolver}={service.id=32}
    {org.springframework.beans.factory.xml.NamespaceHandlerResolver}={service.id=31}
    {org.jnode.driver.DeviceFinder}={org.springframework.osgi.bean.name=bootstrapFinder, Bundle-
SymbolicName=app.node.self.configure.instance2-1-org.tssg.bootstrap.driver, Bundle-Version=1.0.0,
com.springsource.server.app.name=app.node.self.configure.instance2-1, service.id=160}
  Exported packages
    org.tssg.support.jnode; version="1.0.0"[exported]
```

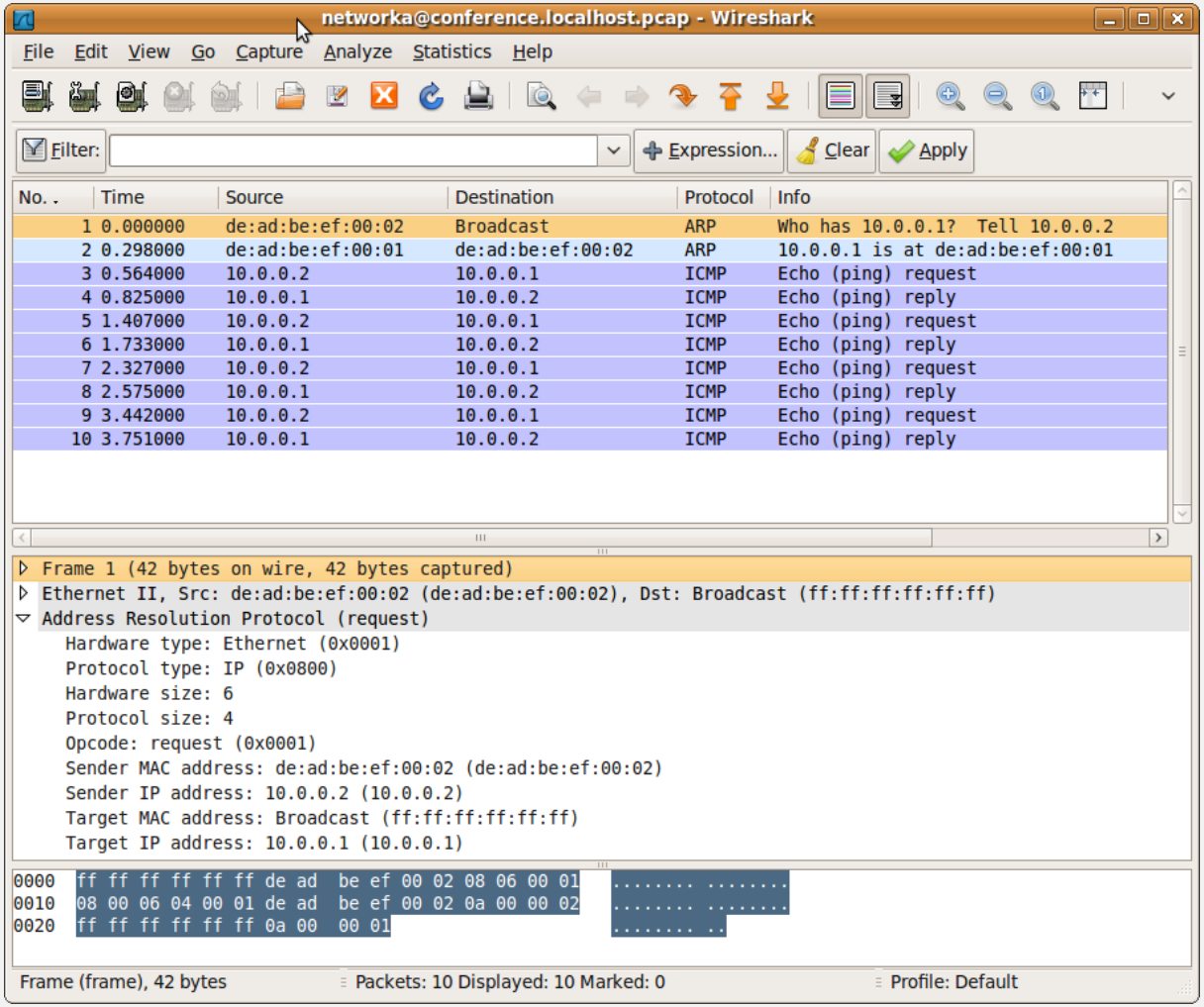
Demo Shots: Node 1 Trace

```
[2009-09-18 10:57:40.298] k Listener Processor (4) org.tssg.config.stack.impl.SetupInterfaces.unknown I Before :
Device:
      bootstrap: MAC-Address BA:D0:00:00:BA:BE MTU 0
            null
Device:
      loopback: MAC-Address 00:00:00:00:00:00 MTU 1500
            null
[2009-09-18 10:57:40.325] k Listener Processor (4) org.tssg.config.stack.impl.SetupInterfaces.unknown I After Loopback :
Device:
      bootstrap: MAC-Address BA:D0:00:00:BA:BE MTU 0
            null
Device:
      loopback: MAC-Address 00:00:00:00:00:00 MTU 1500
            127.0.0.1

[2009-09-18 10:57:41.015] k Listener Processor (4) org.tssg.config.stack.impl.SetupInterfaces.unknown I After Devices :
Device:
      im1: MAC-Address DE:AD:BE:EF:00:02 MTU 1500
            null
Device:
      im0: MAC-Address DE:AD:BE:EF:00:01 MTU 1500
            null
Device:
      bootstrap: MAC-Address BA:D0:00:00:BA:BE MTU 0
            null
Device:
      loopback: MAC-Address 00:00:00:00:00:00 MTU 1500
            127.0.0.1
2009-09-18 10:57:43.025] k Listener Processor (4) org.tssg.config.stack.impl.SetupInterfaces.unknown I ConfigComplete :
Device:
      im1: MAC-Address DE:AD:BE:EF:00:02 MTU 1500
            10.0.1.1
Device:
      im0: MAC-Address DE:AD:BE:EF:00:01 MTU 1500
            10.0.0.1
Device:
      bootstrap: MAC-Address BA:D0:00:00:BA:BE MTU 0
            null
Device:
      loopback: MAC-Address 00:00:00:00:00:00 MTU 1500
            127.0.0.1

[2009-09-18 10:57:43.041] k Listener Processor (4) org.tssg.config.stack.impl.SetupInterfaces.unknown I Route Table :
127.0.0.1 - 0.0.0.0 - 127.0.0.1 - UGH - 0 - loopback
10.0.0.0 - 255.255.255.0 - null - U - 0 - im0
10.0.1.0 - 255.255.255.0 - null - U - 0 - im1
```

Demo Shots: Network Trace (Arp/Ping)



Backup: IM Ping

```
2009-08-07 09:33:59.225] k Listener Processor (0)                org.tssg.transpo
----------------------------------------
CBNE NetworkPacket:
PacketId: 7tFmd-27
Src: subneta@conference.chimera/node2, dest: logger@chimera/logger
Body:
PDU:
DEADBEEF0003DEADBEEF0003080045000001C00020000FF01A7DC0A000
0020A0000010800F7FC0000000300000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000
00000000000000000000000000000000000000000000
Key(Network): SubnetA
Key(Node): node2
----------------------------------------
PKT:Ether: ---- Ethernet2 OSI=2 Frame #1 Captured on 2009-08-07 09:33:59.175 ----
Ether:
Ether:   dst =  de:ad:be:ef:0:3
Ether:   src =  de:ad:be:ef:0:3
Ether: proto =  0x800 "(IP) Internet protocol (v4 or v6)"
Ether:   crc = (Frame check supressed because captured packet has been trunkated)
Ether:
IPv4: ---- IPv4 RFC=791 OSI=3 ----
IPv4:
IPv4:      ver =  4 "Internet Protocol version 4"
IPv4:     hlen =  5 (20 bytes) "No IP options present"
IPv4:      tos = 00000000 0x0
IPv4:            000..... 0x0 = [precedence] "Routine"
IPv4:            ...0.... 0x0 = [delay] "Normal delay"
IPv4:            ....0... 0x0 = [throughtput] "Normal throughput"
IPv4:            .....0.. 0x0 = [reliability] "Normal reliability"
IPv4:            ......00 0x0 = [reserved]
IPv4:      len =  28 (8 bytes of data)
IPv4:       id =  0x2
IPv4:    flags = 000 0x0 (bit fields)
IPv4:            0.. 0x0 = [reserved]
IPv4:            .0. 0x0 = [df] "fragmentation OK"
IPv4:            ..0 0x0 = [mf] "no more fragments"
IPv4:   offset =  0 (bytes)
IPv4:      ttl =  255 (hops)
IPv4:    proto =  1 "(ICMP) Internet Control Message Protocol (RFC792)"
IPv4: checksum =  0xa7dc
IPv4:    saddr =  10.0.0.2
IPv4:    daddr =  10.0.0.1
IPv4:
ICMP: ---- ICMP RFC=792 OSI=3 ----
ICMP:
ICMP:    type =  8 "Echo request"
ICMP:    code =  0
ICMP:     crc =  0xf7fc
ICMP:      id =  0
ICMP: seqence =  3
ICMP: data[0] =  0
```

```
[2009-08-07 09:33:59.286] k Listener Processor (0)
----------------------------------------
CBNE NetworkPacket:
PacketId: 7tFmd-28
Src: subneta@conference.chimera/node1, dest: logger@chimera/logger
Body:
PDU:
DEADBEEF0001DEADBEEF0001080045000001C00020000FF01A7DC0A000
0010A0000020000FFFC00000003
Key(Network): SubnetA
Key(Node): node1
----------------------------------------
PKT:Ether: ---- Ethernet2 OSI=2 Frame #1 Captured on 2009-08-07 09:33:59.238 ----
Ether:
Ether:   dst =  de:ad:be:ef:0:1
Ether:   src =  de:ad:be:ef:0:1
Ether: proto =  0x800 "(IP) Internet protocol (v4 or v6)"
Ether:   crc = (Frame check supressed because captured packet has been trunkated)
Ether:
IPv4: ---- IPv4 RFC=791 OSI=3 ----
IPv4:
IPv4:      ver =  4 "Internet Protocol version 4"
IPv4:     hlen =  5 (20 bytes) "No IP options present"
IPv4:      tos = 00000000 0x0
IPv4:            000..... 0x0 = [precedence] "Routine"
IPv4:            ...0.... 0x0 = [delay] "Normal delay"
IPv4:            ....0... 0x0 = [throughtput] "Normal throughput"
IPv4:            .....0.. 0x0 = [reliability] "Normal reliability"
IPv4:            ......00 0x0 = [reserved]
IPv4:      len =  28 (8 bytes of data)
IPv4:       id =  0x2
IPv4:    flags = 000 0x0 (bit fields)
IPv4:            0.. 0x0 = [reserved]
IPv4:            .0. 0x0 = [df] "fragmentation OK"
IPv4:            ..0 0x0 = [mf] "no more fragments"
IPv4:   offset =  0 (bytes)
IPv4:      ttl =  255 (hops)
IPv4:    proto =  1 "(ICMP) Internet Control Message Protocol (RFC792)"
IPv4: checksum =  0xa7dc
IPv4:    saddr =  10.0.0.1
IPv4:    daddr =  10.0.0.2
IPv4:
ICMP: ---- ICMP RFC=792 OSI=3 ----
ICMP:
ICMP:    type =  0 "Echo reply"
ICMP:    code =  0
ICMP:     crc =  0xffffc
ICMP:      id =  0
```

Node 2 - Ping (Lots of Debug Removed)

```
[2009-08-07 09:33:59.528] server-dm-14        org.tssg.actions.ping.PingCommand.unknown
ping 10.0.0.1
Output:
Ping 10.0.0.1 attempt 0
Reply from 10.0.0.1: 0bytes of data ttl=255 seq=0 time=67ms
Ping 10.0.0.1 attempt 1
Reply from 10.0.0.1: 0bytes of data ttl=255 seq=1 time=64ms
Ping 10.0.0.1 attempt 2
Reply from 10.0.0.1: 0bytes of data ttl=255 seq=2 time=362ms
Ping 10.0.0.1 attempt 3
Reply from 10.0.0.1: 0bytes of data ttl=255 seq=3 time=39ms
-> Packet statistics
4 packets transmitted, 4 packets received
round-trip min/avg/max = 39/133.0/362 ms
```

Backup: Trace Data (netstat / ping)

```
[2009-07-20 16:12:49.159] server-dm-3                    org.tssg.test.NetstatCommand.unknown I netstat:
ipv4: ID 2048
    badhlen 0, badlen 0, badsum 0, fragments 0, ipackets 0, noproto 0,
    nodevaddr 0, opackets 0
    udp: ID 17
        badlen 0, badsum 0, fullsock 0, hdrops 0, ipackets 0, noport 0,
        nopoartbcast 0, opackets 0
    icmp: ID 1
        badlen 0, badsum 0, ipackets 0, opackets 0
    tcp: ID 6
        badlen 0, badsum 0, fullsock 0, hdrops 0, ipackets 0, noport 0,
        nopoartbcast 0, opackets 0

[2009-07-20 16:12:49.161] server-dm-3                    org.tssg.test.NetstatCommand.unknown I netstat:
arp: ID 2054
    badlen 0, ipackets 0, arpreq 0, arpreply 0, rarpreq 0, rarpreply 0,
    opackets 0
```

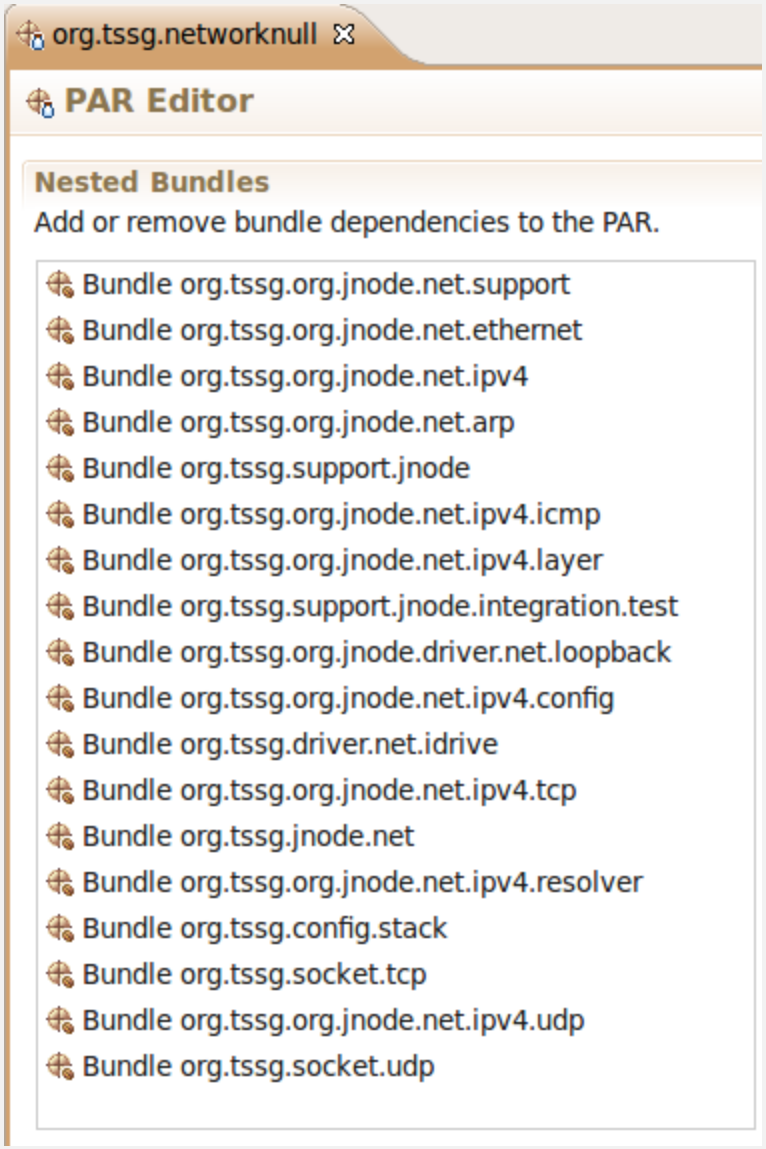
```
[2009-07-20 16:22:54.291] server-dm-3                    org.tssg.test.PingCommand.unknown I
ping localhost
Output:
Ping 127.0.0.1 attempt 0
Reply from 127.0.0.1: 0bytes of data ttl=255 seq=0 time=8ms
Ping 127.0.0.1 attempt 1
Reply from 127.0.0.1: 0bytes of data ttl=255 seq=1 time=10ms
Ping 127.0.0.1 attempt 2
Reply from 127.0.0.1: 0bytes of data ttl=255 seq=2 time=20ms
Ping 127.0.0.1 attempt 3
Reply from 127.0.0.1: 0bytes of data ttl=255 seq=3 time=16ms
-> Packet statistics
4 packets transmitted, 4 packets received
round-trip min/avg/max = 8/13.0/20 ms
```

Backup: Trace Data (TCP Test)

```
Thread-36                                  org.tssg.socket.tcp.SocketServer.unknown I Send(Bar) to Client
loopback-tx                          org.jnode.driver.net.spi.AbstractNetDriver.unknown D <transmit dev=loopback>
loopback-tx                          org.jnode.driver.net.spi.AbstractNetDriver.unknown D </transmit dev=loopback>
net-packet-processor         org.tssg.support.jnode.impl.TssgNetworkLayerManager.unknown I Layer: ipv4 Allowed :true
net-packet-processor                  org.jnode.net.ipv4.layer.IPv4NetworkLayer.unknown I Protocol Match : tcp
net-packet-processor                         org.jnode.net.ipv4.tcp.TCPProtocol.unknown I src: 127.0.0.1:4444 dst: 127.0.0.1:1025
net-packet-processor                         org.jnode.net.ipv4.tcp.TCPProtocol.unknown I cb = local 127.0.0.1:1025, foreign 127.0.0.1:44
net-packet-processor         org.tssg.support.jnode.impl.TssgNetworkLayerManager.unknown I Layer: ipv4 Allowed :true
net-packet-processor                  org.jnode.net.ipv4.layer.IPv4NetworkLayer.unknown I Protocol Match : tcp
net-packet-processor                         org.jnode.net.ipv4.tcp.TCPProtocol.unknown I src: 127.0.0.1:4444 dst: 127.0.0.1:1025
net-packet-processor                         org.jnode.net.ipv4.tcp.TCPProtocol.unknown I cb = local 127.0.0.1:1025, foreign 127.0.0.1:44
net-packet-processor                        org.jnode.net.ipv4.IPv4RoutingTable.unknown I Search : 127.0.0.1
loopback-tx                          org.jnode.driver.net.spi.AbstractNetDriver.unknown D <transmit dev=loopback>
loopback-tx                          org.jnode.driver.net.spi.AbstractNetDriver.unknown D </transmit dev=loopback>
net-packet-processor         org.tssg.support.jnode.impl.TssgNetworkLayerManager.unknown I Layer: ipv4 Allowed :true
net-packet-processor                  org.jnode.net.ipv4.layer.IPv4NetworkLayer.unknown I Protocol Match : tcp
net-packet-processor                         org.jnode.net.ipv4.tcp.TCPProtocol.unknown I src: 127.0.0.1:1025 dst: 127.0.0.1:4444
net-packet-processor                         org.jnode.net.ipv4.tcp.TCPProtocol.unknown I cb = local 127.0.0.1:4444, foreign 127.0.0.1:10
Thread-37                                    org.tssg.socket.tcp.SocketClient.unknown I SocketClient: Recvd(1) from Server : [Bar]
Thread-37                                    org.tssg.socket.tcp.SocketClient.unknown I SocketClient: Send(Foo) to Server
Thread-37                                   org.jnode.net.ipv4.IPv4RoutingTable.unknown I Search : 127.0.0.1
loopback-tx                          org.jnode.driver.net.spi.AbstractNetDriver.unknown D <transmit dev=loopback>
loopback-tx                          org.jnode.driver.net.spi.AbstractNetDriver.unknown D </transmit dev=loopback>
net-packet-processor         org.tssg.support.jnode.impl.TssgNetworkLayerManager.unknown I Layer: ipv4 Allowed :true
net-packet-processor                  org.jnode.net.ipv4.layer.IPv4NetworkLayer.unknown I Protocol Match : tcp
```

Backup: Bundles@eclipse

- org.tssg.config.stack
- org.tssg.driver.net.idrive
- org.tssg.jnode.net
- org.tssg.network
- org.tssg.network.commands
- org.tssg.org.jnode.driver.net.loopback
- org.tssg.org.jnode.net.arp
- org.tssg.org.jnode.net.ethernet
- org.tssg.org.jnode.net.ipv4
- org.tssg.org.jnode.net.ipv4.config
- org.tssg.org.jnode.net.ipv4.icmp
- org.tssg.org.jnode.net.ipv4.layer
- org.tssg.org.jnode.net.ipv4.raw
- org.tssg.org.jnode.net.ipv4.resolver
- org.tssg.org.jnode.net.ipv4.tcp
- org.tssg.org.jnode.net.ipv4.udp
- org.tssg.org.jnode.net.support
- org.tssg.socket.tcp
- org.tssg.socket.udp
- org.tssg.support.jnode
- org.tssg.support.jnode.integration.test
- org.tssg.transport.im.api
- org.tssg.transport.im.manager
- org.tssg.webapp



Backup: Java Packages / Deps examples

- jnode.net
  - Authenticator.java
  - DatagramPacket.java
  - DatagramSocket.java
  - DatagramSocketImpl.java
  - DatagramSocketImplFactory.java
  - ExSocketOptions.java
  - Inet4Address.java
  - Inet6Address.java
  - InetAddress.java
  - InetSocketAddress.java
  - MulticastSocket.java
  - NetPermission.java
  - NetworkInterface.java
  - PasswordAuthentication.java
  - PlainDatagramSocketImpl.java
  - PlainDatagramSocketImplFactory.java
  - Proxy.java
  - ResolverCache.java
  - ServerSocket.java
  - Socket.java
  - SocketAddress.java
  - SocketImpl.java
  - SocketImplFactory.java
  - VMInetAddress.java
  - VMNetAPI.java
  - VMNetDevice.java
  - VMNetUtils.java
  - VMNetworkInterface.java

- org.jnode.net.ipv4.tcp
  - TCPConstants.java
  - TCPControlBlock.java
  - TCPControlBlockList.java
  - TCPDataBuffer.java
  - TCPHeader.java
  - TCPInChannel.java
  - TCPInputStream.java
  - TCPInSegment.java
  - TCPOutChannel.java
  - TCPOutputStream.java
  - TCPOutSegment.java
  - TCPProtocol.java
  - TCPSegment.java
  - TCPSocketImpl.java
  - TCPSocketImplFactory.java
  - TCPStatistics.java
  - TCPTimer.java
  - TCPUtils.java

- org.jnode.net.ipv4.datagram
  - AbstractDatagramSocketImpl.java
- org.jnode.net.ipv4.udp
  - PlainUDPDatagramSocketImpl.java
  - UDPConstants.java
  - UDPControlBlock.java
  - UDPDatagramSocketImpl.java
  - UDPDatagramSocketImplFactory.java
  - UDPHeader.java
  - UDPProtocol.java
  - UDPStatistics.java

- org.tssg.socket.udp
  - SocketClient.java
  - SocketServer.java

- org.tssg.socket.tcp
  - SocketClient.java
  - SocketServer.java

```
<osgi:service id="ipv4NetworkLayerService" ref="ipv4NetworkLayerBean">
    <osgi:interfaces>
        <value>org.jnode.net.ipv4.IPv4Service
        </value>
        <value>org.jnode.net.NetworkLayer</value>
    </osgi:interfaces>
</osgi:service>

<osgi:reference id="arpService" interface="org.jnode.net.arp.ARPService"
    bean-name="arpNetworkLayerBean" />
<osgi:reference id="resolverService" interface="org.jnode.net.Resolver"
    bean-name="hostFileResolverBean" />
```