Building Highly-Dynamic Battlefield Network Infrastructure Using JXTA™ Technology

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TS-3527

Goal of This Talk

Learn about the JXTA™ Technology and its use to build highly-dynamic integrated military battlefield network

Agenda

Future Combat System (FCS) Program Overview

Internet History and JXTA Technology Overview

JXTA Technology Sample Programming

Other Military Projects Using JXTA Technology

Summary

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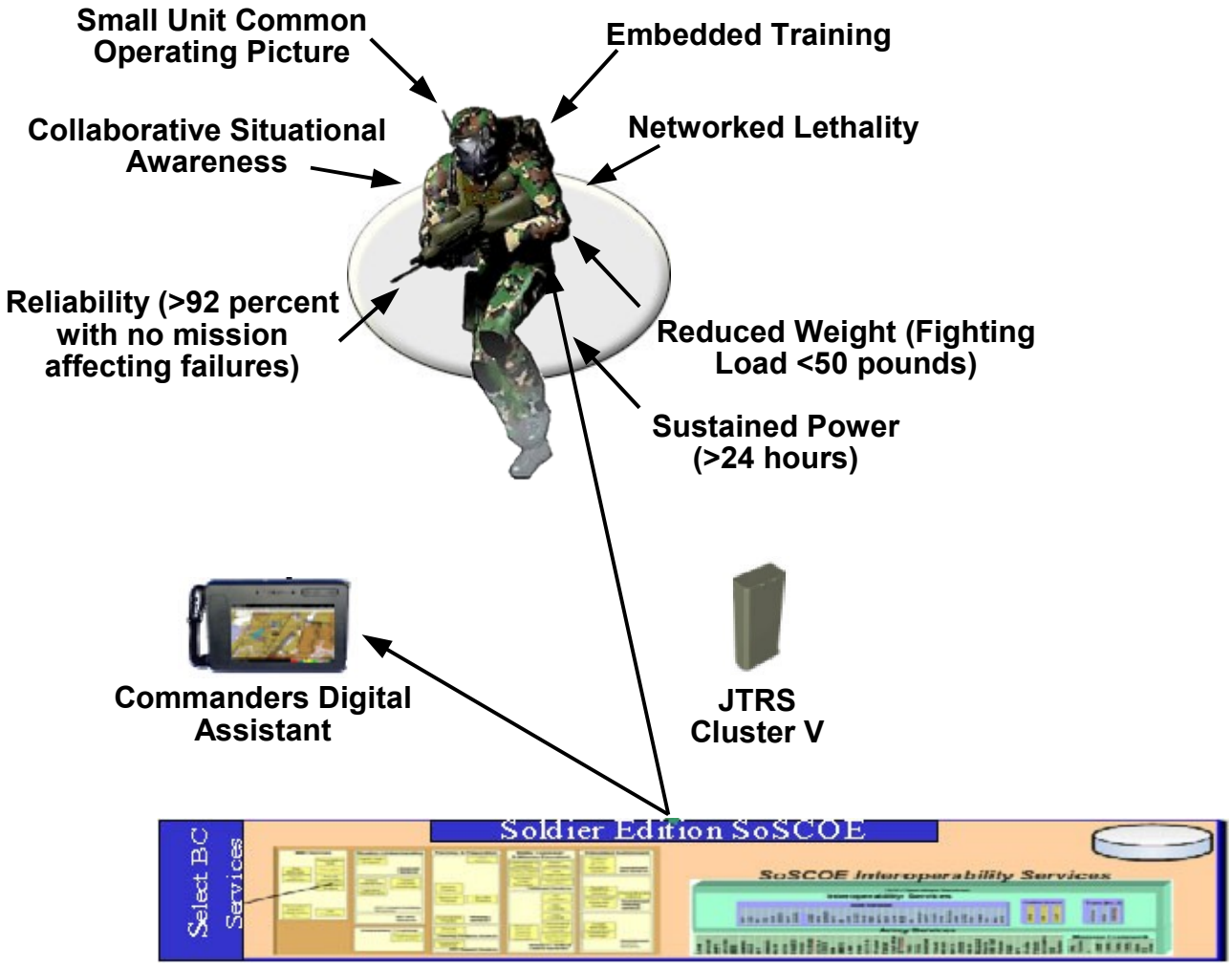
Future Military Battlefield Networks

- Multiple Integrated networks
- Highly-dynamic
- No single point of failures
- Multiple security levels
- Multiple priority QoS
- Internet scale

US Army Future Combat System (FCS) Program

The FCS program aims to link soldiers to a wide range of weapons, sensors, and information systems by means of a mobile ad hoc network architecture that will enable unprecedented levels of joint interoperability, shared situational awareness and the ability to execute highly synchronized mission operations.

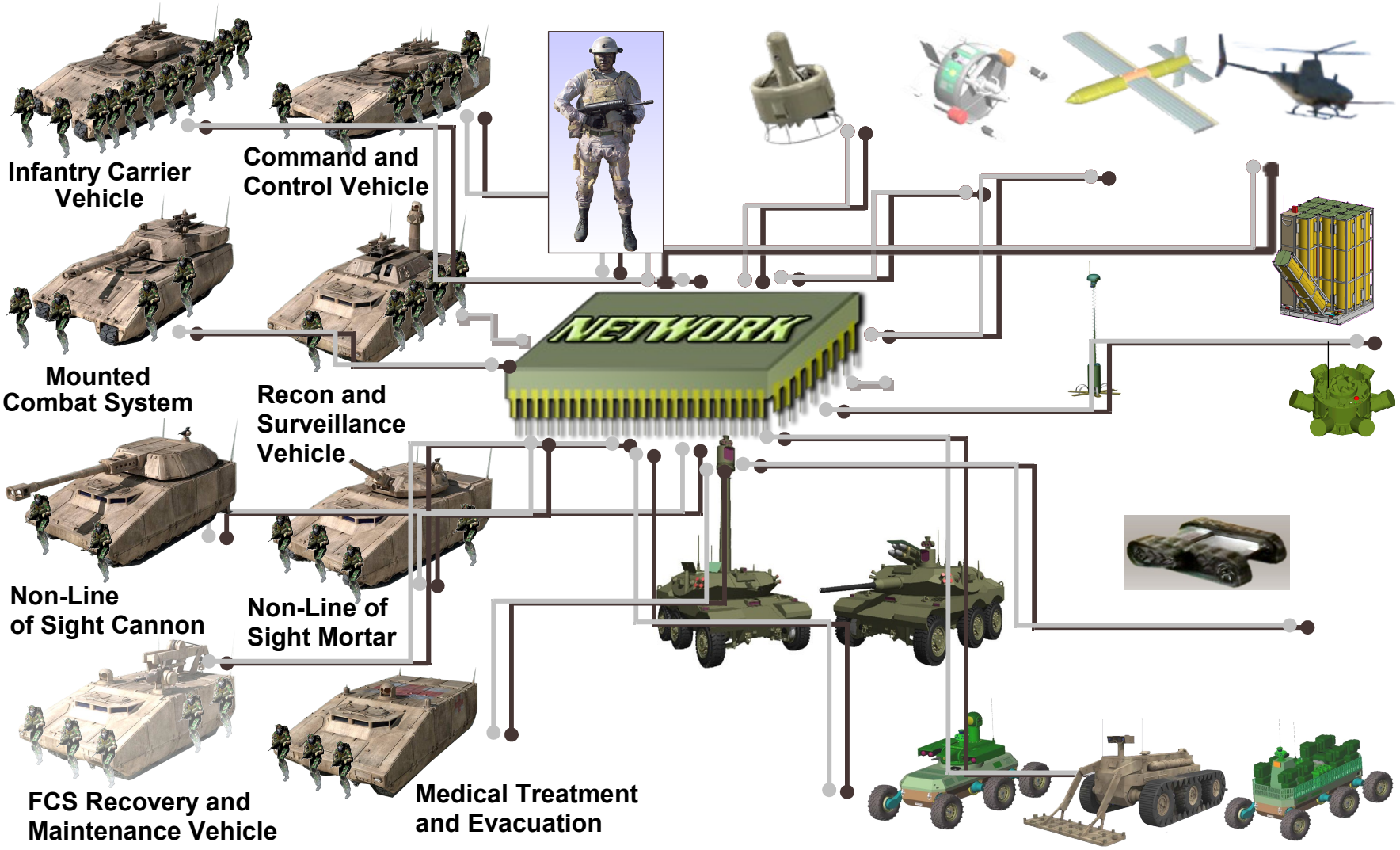
FCS Soldier of the Future



FCS Program Overview

- In 2000, FCS program is initially funded by DARPA and US Army
- Multi-billion dollars project over the next 10–15 years
- In 2002, Boeing and Science Applications International Corp. (SAIC) were awarded the FCS Concept and Tech development contract and act as the FCS Lead System Integrator (LSI) team
- In 2004, extra fundings accelerated the FCS program with initial deployment now expected in 2008
- FCS is a “system of systems” composed of 18 sub-systems

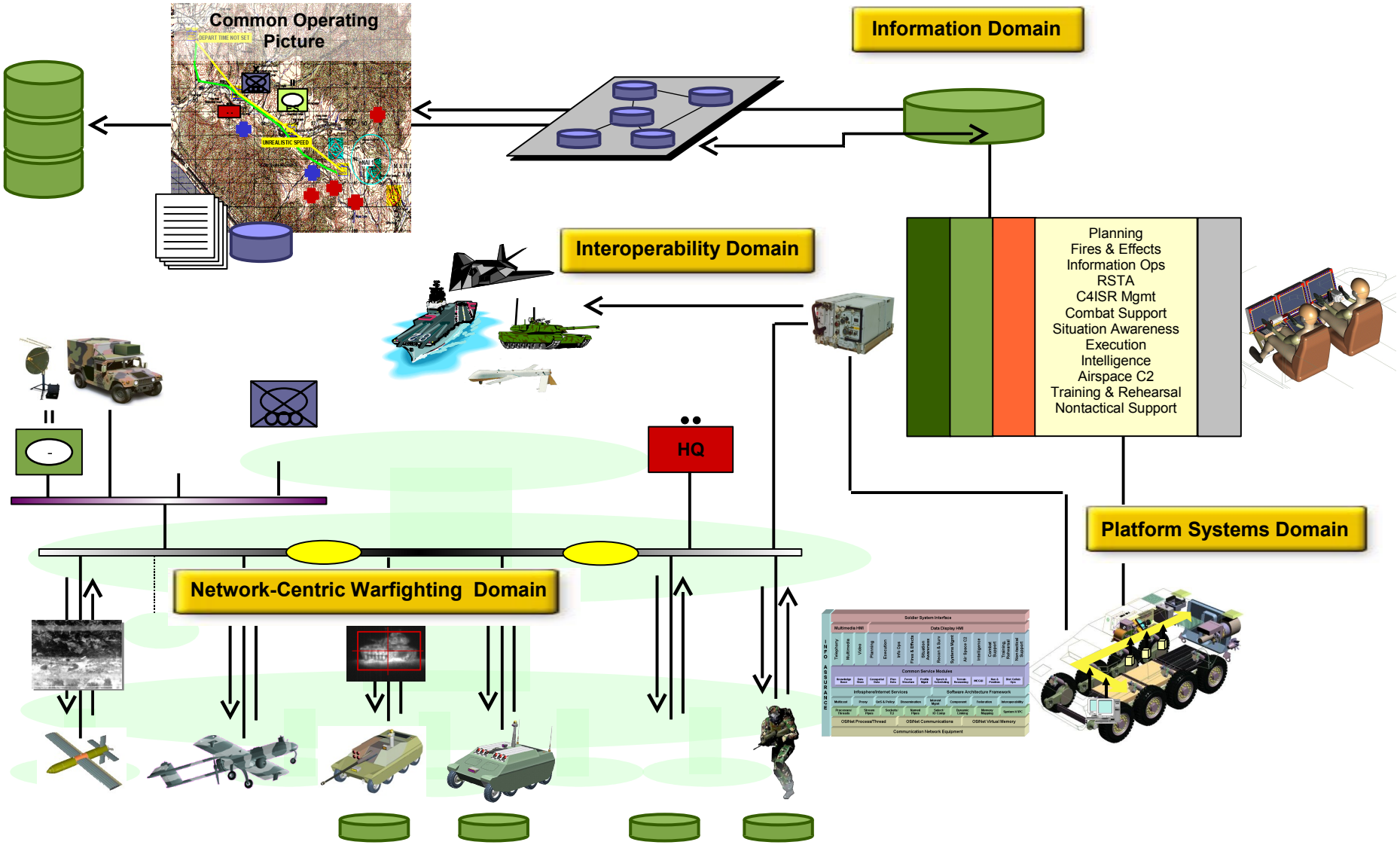
FCS: a Networked "System of Systems"



FCS Unique Characteristics

- Integrated network (satellites, planes, soldiers, vehicles, sensors and unmanned vehicles) for land navigation, perception, world-modeling, behavior generation to provide a semi-autonomous mobility capability
- A battle network system that permits understanding and real-time decisions
- Enhance survivability by decentralizing battle space coverage and situational awareness
- Joint force command, inter-agency and multi-national forces information sharing
- A multi-level security network

Future Combat Systems Architecture Overview



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Internet History (Chapter I)

- The internet was originally built for military purpose
- 60's–70's: the golden years
  - BBN ARPANET and IMP Infrastructure
  - Connecting fairly static computers (workstations and servers)
  - Decentralized Source Addressing (UUCP)
    - Example: newyork!dehli!moscow!user
  - IP Dynamic routing infrastructure

Internet History (Chapter II)

- 80's–90's: the wrong turns!
  - Centralized Domain Name Service (DNS)
    - Bias towards static workstations/servers
  - Physical Addressing Model (URL)
    - Fix IP addresses mapping to contents
  - Point-to-point communication network (Multicast Anycast limitation)
  - Domain topology controlled by network administrators, not applications or users
  - No network scoping and discovery mechanisms

Internet History (Chapter III)

- 2000's: back to its origin
  - The "P2P" revolution started by Napster
    - Highly-resilient networks that are difficult to shutdown
    - Self-organized and managed network
    - Highly-dynamic and decentralized infrastructure
    - Overlay network and virtual addressing (content addressing network)
      - From IP address to logical ID address

JXTA Technology Vision

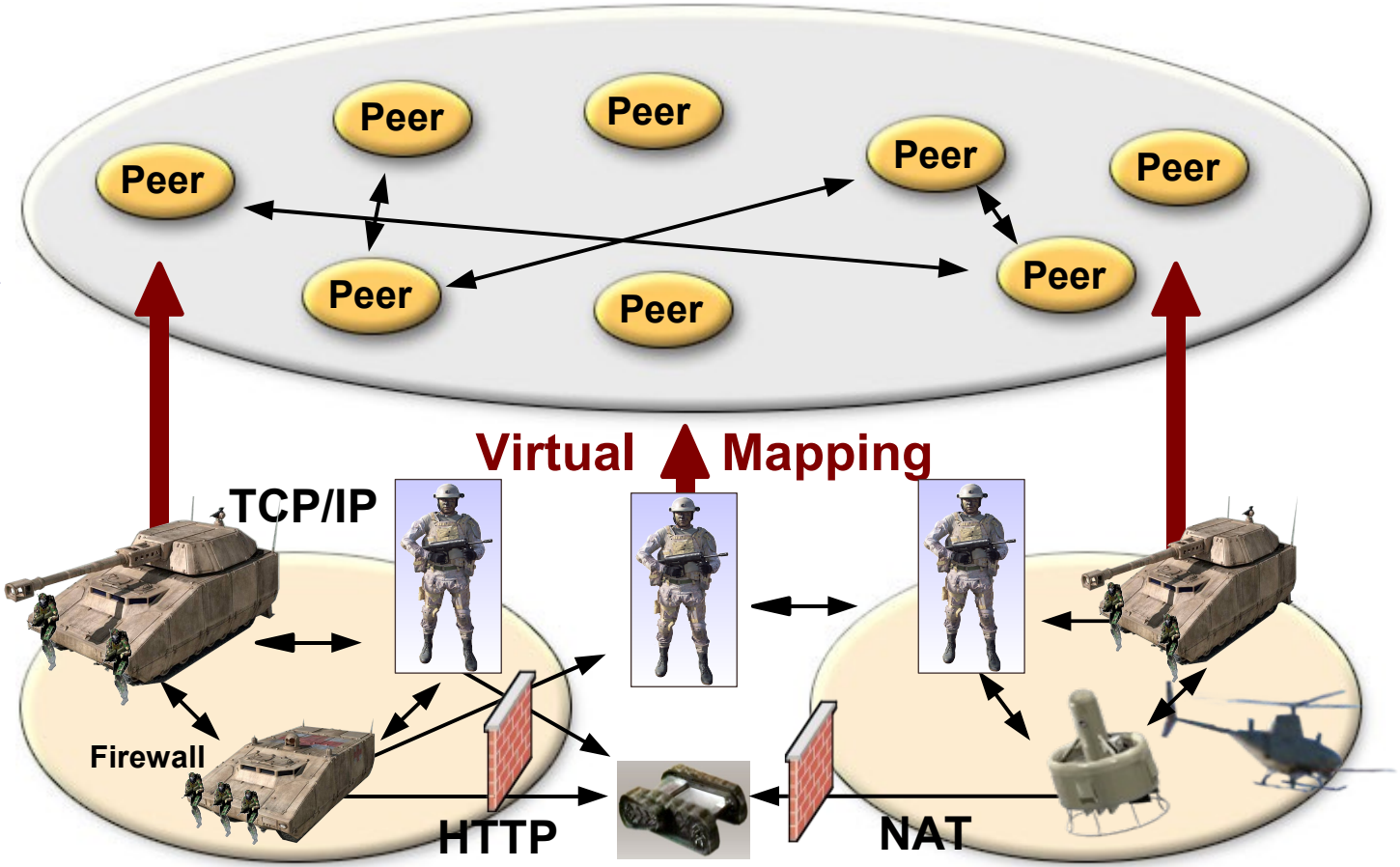
Provide a standard P2P Internet network protocol

- A dynamic and decentralized integrated network infrastructure (Internet, Enterprise, Home, GPRS, Satellite, Wi-fi, proximity)
- A virtual overlay network for connecting people, systems, and things
- A multi-level security network

JXTA Technology Overview

- A network **protocol** for creating fully decentralized virtual Internet peer-to-peer (P2P) network
  - A set of protocols (XML-based)
  - Works with any language, OS, network, and service models
    - Java™ SE, Java ME and C/C++/.net implementations
  - A virtual Internet overlay
  - Decentralized DHT routing/discovery protocol
  - A set of mechanisms, pluggable policies
  - An Open Source project: www.jxta.org

JXTA Technology Virtual Network



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JXTA Technology Within FCS

BOEING

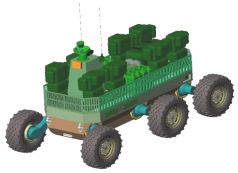
- JXTA Technology was selected as the device discovery infrastructure for FCS
- Self-organizing and resilient network
- Decentralized device advertisement and discovery
- Support highly-dynamic network environment
- Platform-neutral
- Open-source and royalty free technology

JXTA Technology Peer Population

- Micro peers



- Standard peers

- Super peers:
  - Rendezvous (Searching)
  - Relay peer (Communicating)
  - Proxy peer (Provisioning)

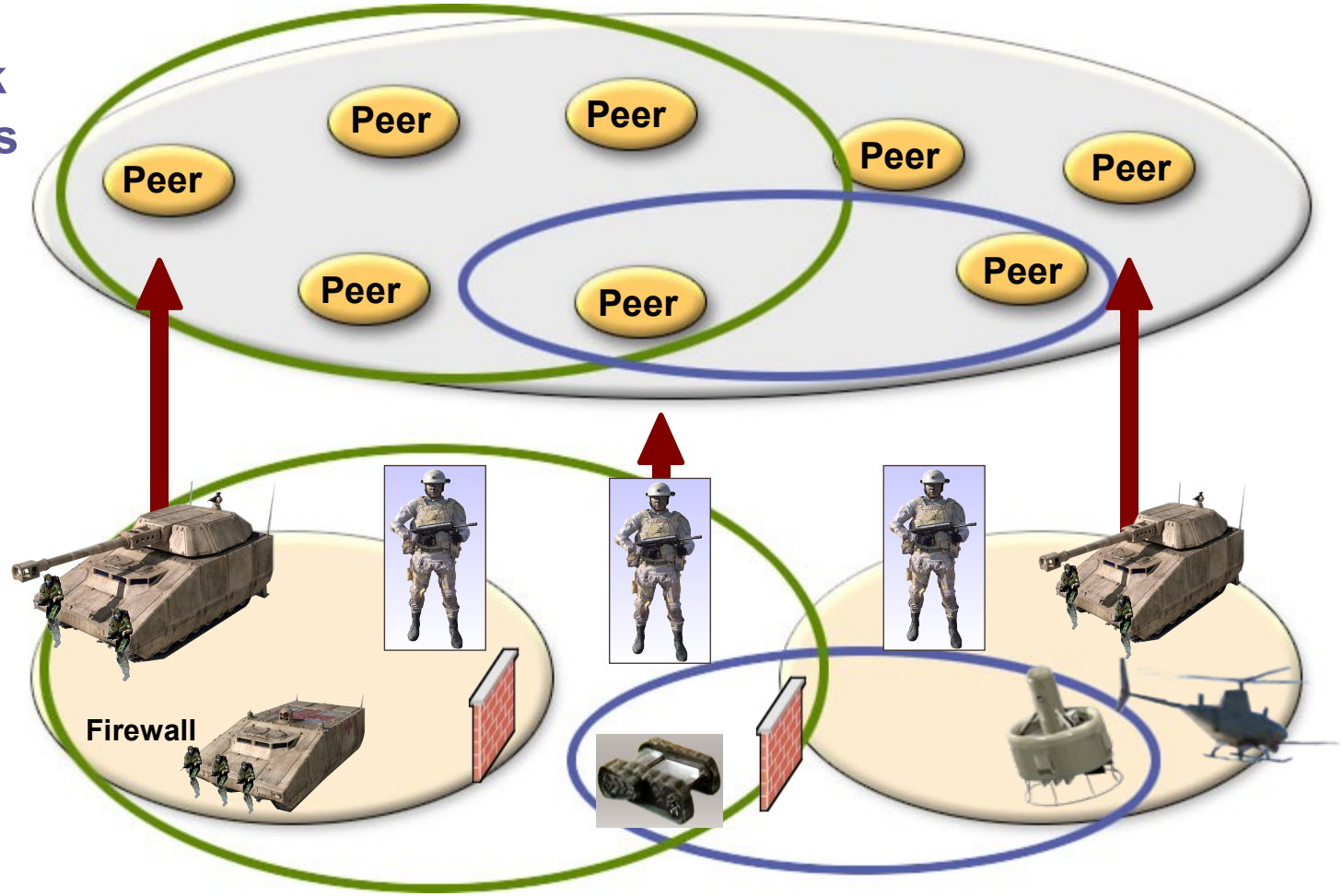



Starting a JXTA Peer Code Sample

```
static PeerGroup netPeerGroup = null;

try {
     // instantiate a JXTA Configurator profile
     JxtaConfigurator conf = new JxtaConfigurator();
     conf.setName(NAME);
     conf.setSecurity(CREDENTIAL, PASSWORD);

     // persist the configuration
     this.configuration = conf.getPlatformConfig();
     conf.save();

     // create and start the default JXTA NetPeerGroup
     netPeerGroup = PeerGroupFactory.newNetPeerGroup();

    }
    catch (PeerGroupException e) {
     // error message
    }
```

Dynamic and Ad Hoc Network Domains

JXTA Network Domains



Military Network

Creating and Joining a New Peergroup

- Peergroup service signature
- Peergroup membership
  - Used to apply for peergroup membership, join a peergroup, and resign from a peergroup
  - Enables peer to establish an identity within a peergroup
  - Identities used by services to determine the capabilities which should be offered to the peer
- Peergroup access control service

Creating a New Peergroup Code Sample

```
PeerGroupAdvertisement adv;

// create a new all purpose group advertisement
ModuleImplAdvertisement implAdv =
  myGroup.getAllPurposePeerGroupImplAdvertisement();
// instantiate the new group
PeerGroup pg = myGroup.newGroup(null,  // Assign new group ID
               implAdv,       // The implem. adv
               "COMM",         // Group name
               "NetPeerGroup"); // Helpful descr.

// print the name of the group and its peergroup ID
 adv = pg.getPeerGroupAdvertisement();
 PeerGroupID GID = adv.getPeerGroupID();
 System.out.println("  Group = " +adv.getName() +
                    "\n  Group ID = " + GID.toString());
```

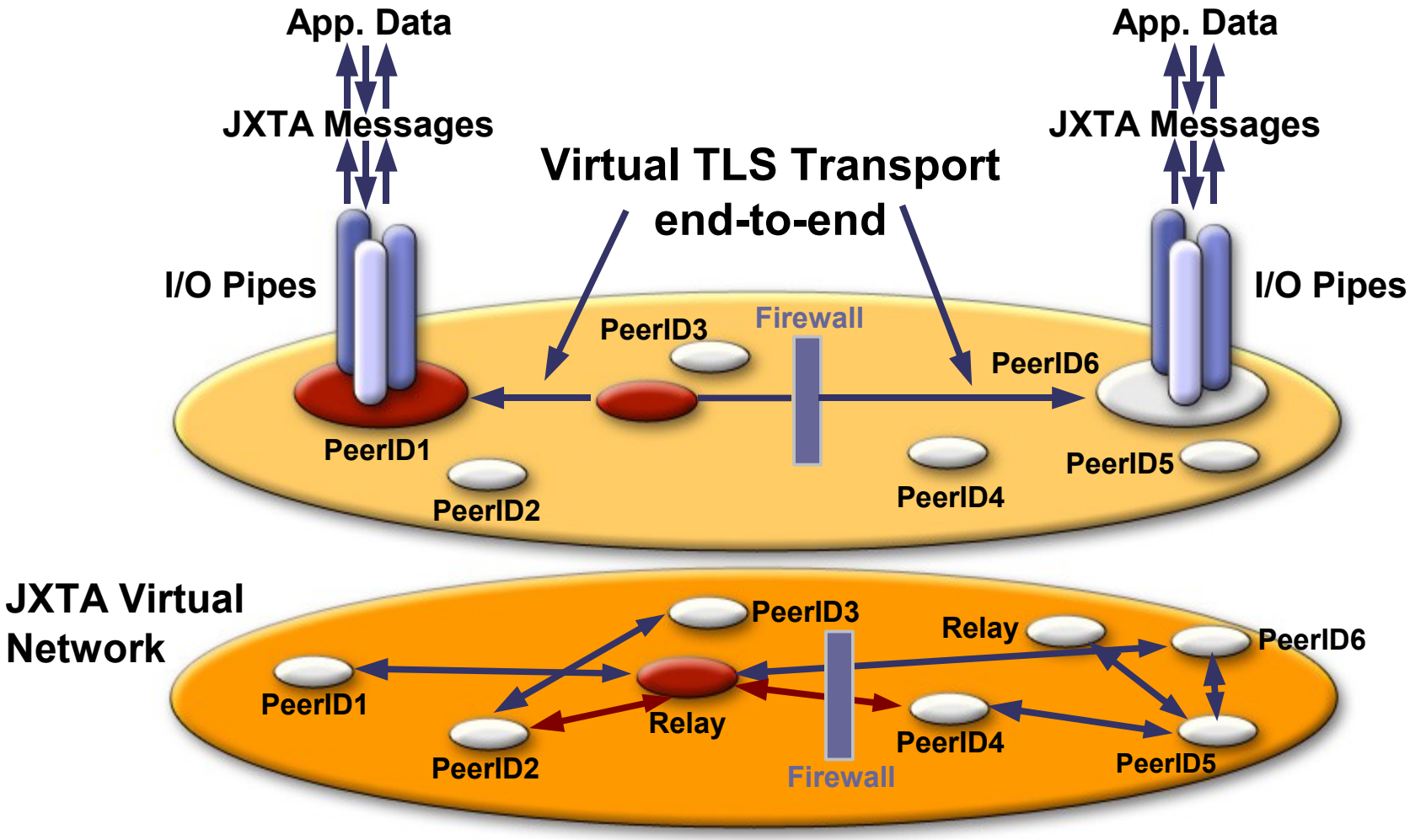
Joining a New Peergroup Code Sample

```
// Generate the credentials for the Peer Group
AuthenticationCredential authCred =
new AuthenticationCredential(pg, null, myCreds );

// Get the MembershipService from the peer group
MembershipService membership = pg.getMembershipService();

// Get the Authenticator from the Authentication creds
Authenticator auth = membership.apply( authCred );

// Check if everything is okay to join the group
if (auth.isReadyForJoin()){
    Credential myCred = membership.join(auth);
    // Group joined
} else {
    // Failed to join the group
}
```

Security

- PKI-based
- TLS secure communication channels
- Each peer can act as its own CA
- Peers issue certificates for each service they offer
- Peer certificates are distributed as part the peer advertisements
- Each Peer Groups define its own membership and authentication requirements

The Virtual TLS Network



Device Discovery

- JXTA Advertisements
  - XML documents that provide a platform-independent description of devices
- Common operations
  - Create/Publish/Discover
- Advertisements can be cached by peers
- Each advertisement published with a time-to-live
  - Relative expiration date
  - When expired, advertisements are deleted

Rendezvous Super-Peers

- Each peergroup has its own set of dynamically elected rendezvous super-peers
  - Rendezvous peers cache resource indices (Distributed Hash Table decentralized index)
  - Edge discovery queries are routed between rendezvous peers
  - Any peer may become a rendezvous super-peer (auto-Rendezvous election and dynamic failover)
- Peers can be pre-configured to know certain rendezvous super-peers (satellite), and can discover them dynamically (planes, C2 vehicles, soldiers)

Discovery Code Sample

```
public class findDevice implements DiscoveryListener {

    private PeerGroup netPeerGroup  = null;
    private DiscoveryService discovery;
    PeerAdvertisement peerAdv;

    ...
    // Join NetPeerGroup
    netPeerGroup = PeerGroupFactory.newNetPeerGroup();
    ...
    // Get the discovery service from the current peergroup
    discovery = netPeerGroup.getDiscoveryService();
    // Register discovery listener
   discovery.addDiscoveryListener(this);

   // Issue a discovery request
   discovery.getRemoteAdvertisements(null,
                DiscoveryService.ADV,
                "Device_Name", "COMM-TR2_345", 5, null);
```

Discovery Code Sample (Suite)

```
Public void discoveryEvent(DiscoveryEvent ev) {

    DiscoveryResponseMsg res = ev.getResponse();

    // Get the responding peer's advertisement
    // get the peer advertisement
    PeerAdvertisement peerAdv = res.getPeerAdvertisement();
    if (peerAdv != null) {
        name = peerAdv.getName();
    }

    System.out.println(" [  Got a Discovery Response ["+
      res.getResponseCount()+ " elements]  from peer : " +
      name +"  ]");

    // get the discovered Advertisements....
      Enumeration responses = res.getAdvertisements();
    }
```

Communication via JXTA Socket

- Socket is the main mechanism for exchanging messages between JXTA services
- Similar semantic than java.net.Socket
  - Ease of use of JXTA Technology
- Several types of Socket are available:
  - JxtaUnicast—reliable, unsecure
  - JxtaUnicastSecure—reliable secure
  - JxtaPropagate—propagated, unreliable

Server Socket Code Sample

```
// Create a new pipe advertisement
PipeAdvertisement pipeAdv =(PipeAdvertisement)
              AdvertisementFactory.NewAdvertisement(
       PipeAdvertisement.getAdvertisementType());
// Pipe ID acts as logical service address
pipeAdv.setPipeID((PipeID)IDFactory.newPipeID(
       pg.getPeerGroupID()));
pipeAdv.setName("COMM-INFO");
// Set the pipe type
pipeAdv.setType(PipeService.UnicastType);


// Instantiate a Jxta server socket
server = new JxtaServerSocket(netPeerGroup, pipeAdv);
// Block until we receive new messages
server.setSoTimeout(0);

// Receive messages
Byte[] data = null;
InputStream is = server.getInputStream();
is.read(data);
```

Client Socket Code Sample

```
OutputStream os = null;
InputStream is = null;
Byte[] message = msg.getBytes();
Byte[] data = null

// Create a new socket
socket = new JxtaSocket(netPeerGroup,pipeAdv);

// Get the output and input stream associated with this
// socket
os = socket.getOutputStream();
is = socket.getInputStream();

// Send a message
os.write(message);

// Receive a message
is.read(data);
```

What Does JXTA Technology Enable ?

- Virtual network addressing
  - JXTA addresses can be dynamically mapped to different network IP and non-IP addresses
- Removing network single point of failures
  - Fully decentralized and distributed network services (ID, DNS, Directory, multicast, etc.)
- Enabling secure dynamic and ad hoc virtual network domains
  - “On-demand” VPN
  - Capture transient and ad hoc interactions
- DHT Routing resource discovery
  - Distributed resource indexer using adhoc RendezVous super-peers

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Communication and Control Battlefield Network using JXTA Technology

- Argon Engineering
  - Navy battleships command and control network communication infrastructure
  - Build resilient and ad hoc network between battleships
  - Internal project

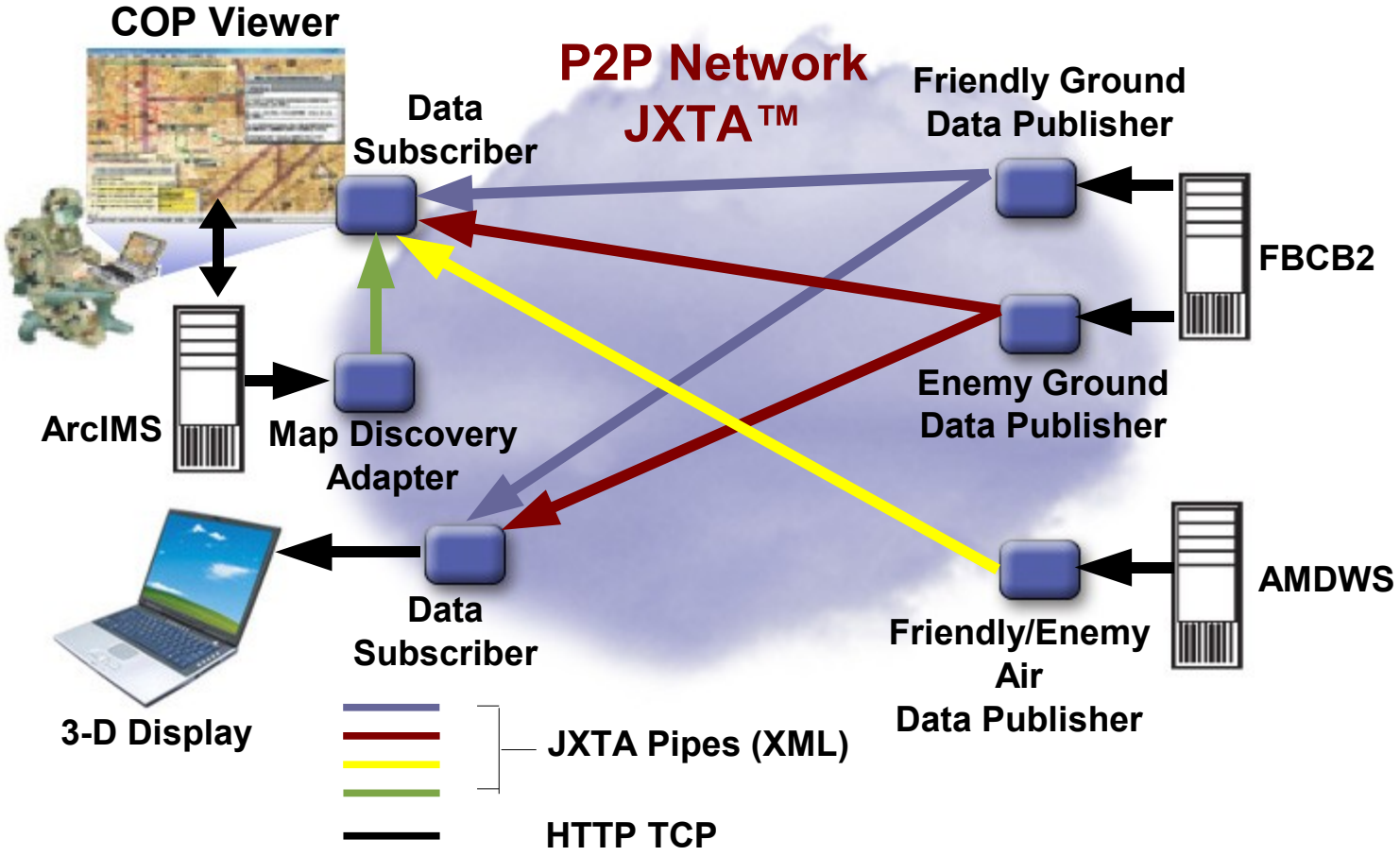
JXTA Network-Centric Warfare

NORTHROP GRUMMAN

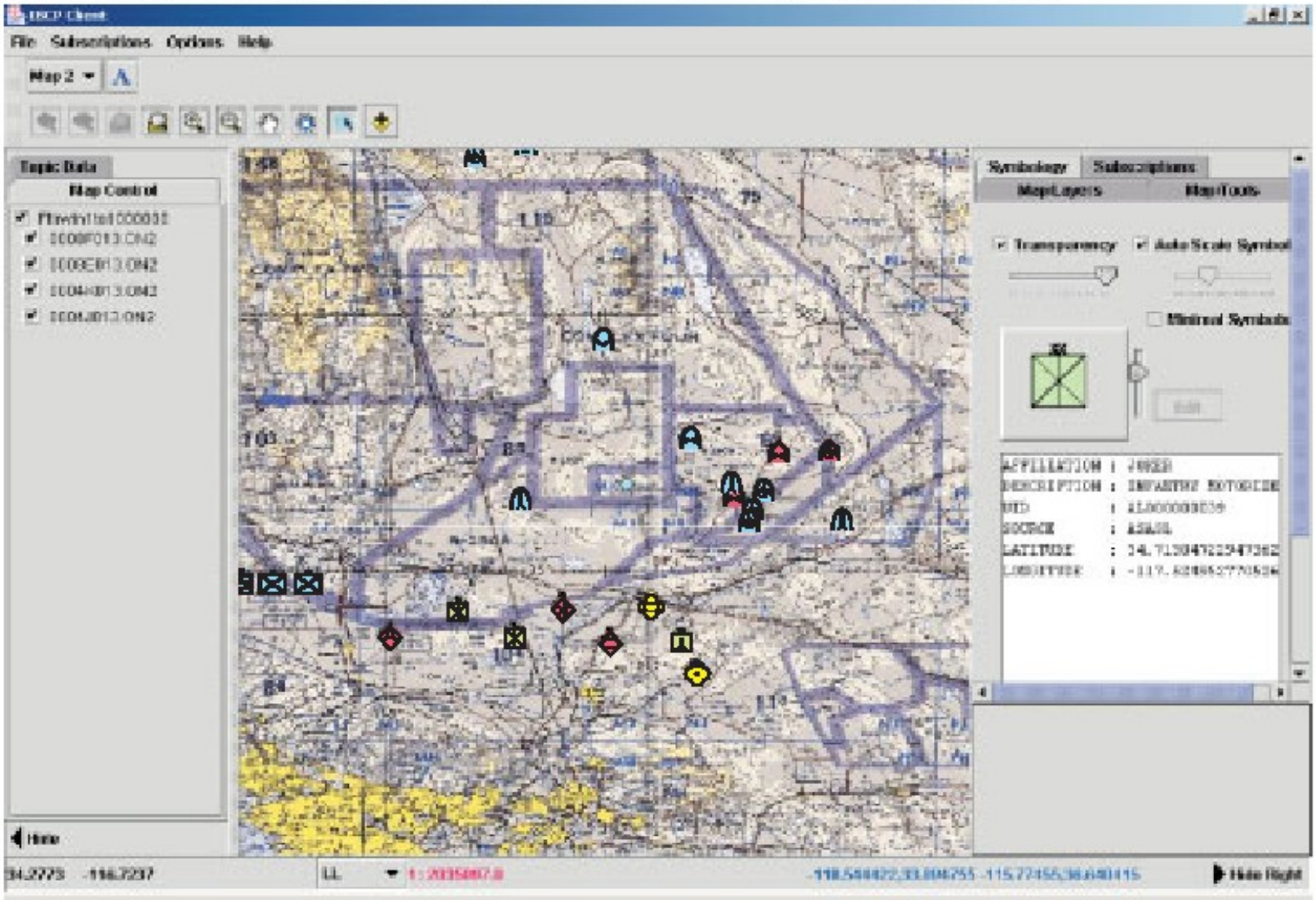
- Northrop Grumman Mission Systems, Tactical Systems Division
  - Integrated battlefield visualization system
  - Provide near real-time integrated data from multiple distributed source
  - Display the location of and information on friendly/enemy ground and air units, geophysical items (bridges, supply points, etc.), and battlefield geometries (boundaries, engagement zones)

Network-Centric Integrated Battlefield Picture

Toward network-centric warfare for commanders



b. IBCP/COP viewer: Friendly, enemy, and unknown ground and air units



Sensor Military Networks

BBN TECHNOLOGIES
A Verizon Company

- SPIDAR: Networking motion sensors to detect intruders or underwater acoustic sensors that can detect submarines
- Peer-to-peer communications between sensors, so sensors can take advantage of other sensors' observations without requiring a fully-connected, high-bandwidth network
- Built P2P sensor webs that link disparate peers, including heterogeneous sensors, remote devices, autonomous software agents, and human operators
- The SPIDAR toolkit is the enabling technology behind BBN's Smart Security Web for Homeland Defense applications, including intrusion detection and perimeter defense system

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- JXTA brings devices, services, and network(s) together independently of their physical network connections
- JXTA enables secure interactions among highly-dynamic peers
- JXTA simplifies the network and operating environment
  - Dynamic and self-configuration
- Ubiquitous resource representation and access
  - Any device, anywhere (find it, get it, use it)

Resources

- JXTA
  - JXTA Community Web Site
    - www.jxta.org
  - Mailing Lists
    - discuss@jxta.org
    - dev@jxta.org
  - JXTA Java SE
    - platform.jxta.org
  - JXTA Java ME (CDC/CLDC)
    - jxme.jxta.org
  - JXTA C/C++/.net/Mono
    - jxta-c.jxta.org
- FCS
  - www.boeing.com/fcs

Q&A

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