
# Internetworking for Coalition Interoperability

by

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# INTRODUCTION

**Under a multilateral MOU involving Canada, France, Germany, Italy, The Netherlands, Norway, The United Kingdom, the United States, and in cooperation with the NATO C3 Agency, a collaborative R&D and demonstration project was started in internetworking technologies essential for coalition interoperability.**

**The project looks for technical solutions that will enable secure, multimedia (voice, data, messaging, imagery and video) communications over static and mobile, narrow and wide band, military and civilian networks. The focus is on the suitability of IPv6 protocols to support military needs in network management, security, mobility, routing, QoS, and directories/DNS.**

**The interrelation of basic building-block technologies are investigated and integrated into a global IP network-of-networks that was created for testing and demonstration in a practical coalition network environment.**

# OBJECTIVE

**Perform collaborative research and development leading to a practical demonstration of a global military internetwork architecture that is**

**interoperable**
**manageable**
**secure**
**mobile**

**across various military and civil networks, based on**

**existing and emerging standards,**
**commercial services and products, and**

**provides evolutionary transition from IPv4 to IPv6 for future coalition networks.**

# FUNDAMENTAL PRECEPTS

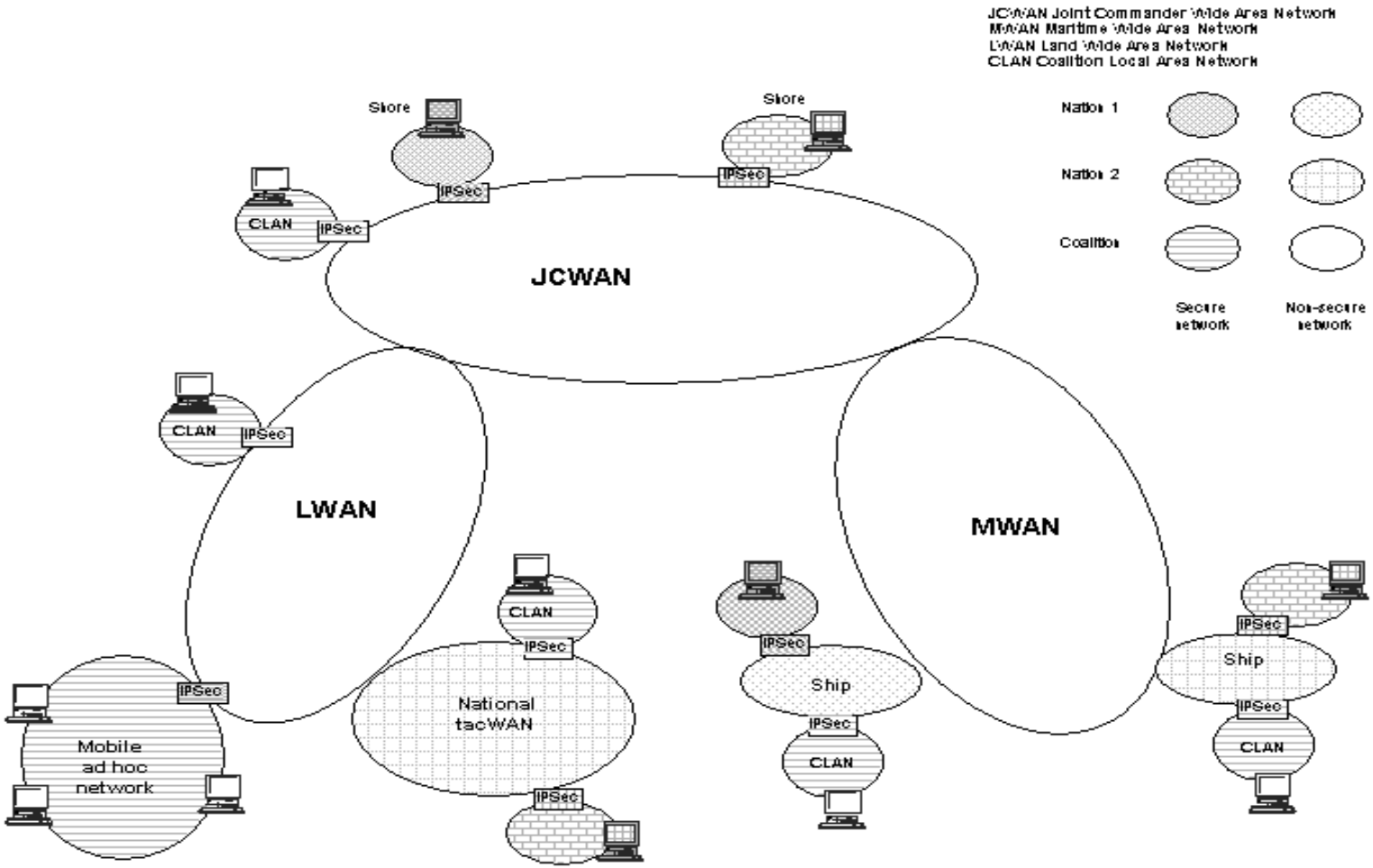
- Interoperability among existing but dissimilar systems vice new system development
  - Addresses communications interoperability in coalition operations
- Exploits commercial standards, products and services
  - Avoids unnecessary duplication
  - Engage in development where commercial technologies are nonexistent or inadequate for military needs
- Military needs differ from civilian environment
  - Civil telecommunications typically high BW fiber-optic links with low error rates
  - Military communications typically narrow BW radio frequency bearers with much higher error rates
- Collaborative R&D vice systems development/acquisition
  - Cooperation vice competition

# OPERATIONAL SCENARIO

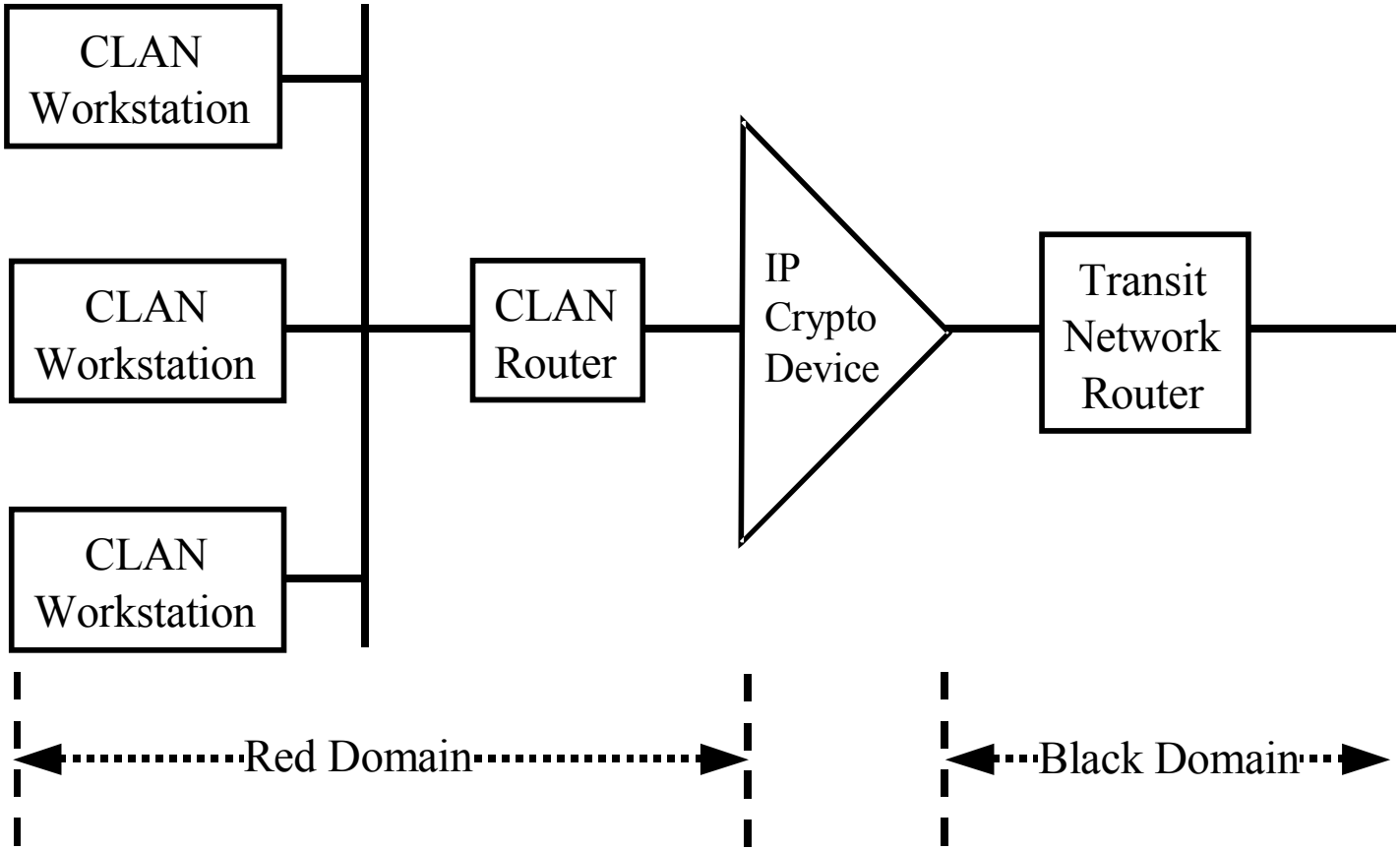

**Multinational air, land, and sea forces**
**Secure, interoperable, manageable comms**
**Dynamic network topology**

**Numerous mobile nodes**
**Multiple management domains**
**Integrated with commercial services**

# OPERATIONAL ARCHITECTURE



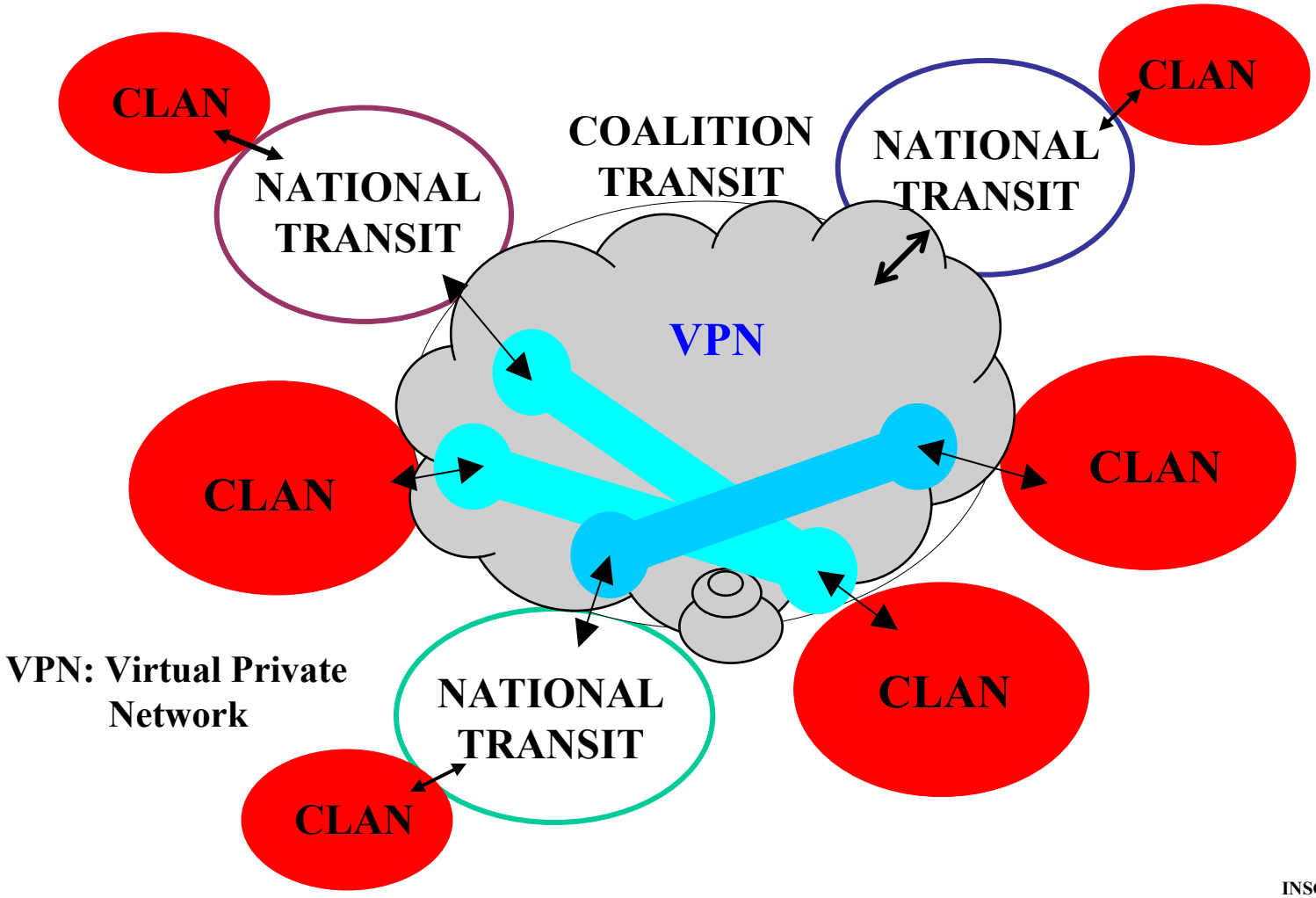
# CLAN GENERIC ARCHITECTURE



# DESIGN FEATURES OF THE DEMONSTRATION ARCHITECTURE

- All nations form a single coalition with one or more coalition LANs (CLANs)
- All CLANs are at the same security level
- There are two coalition security domains (red and black) separated by IPSec
- CLANs will form one closed Virtual Private Network (VPN)
- Some nations will have national LANs, each being a closed VPN
- The JCWAN, the LWAN and the MWAN will be separate interconnected Autonomous Systems (AS)
- IPv4 will not be supported in the WANs
- Access to the black Wide Area Service is IPv6 only
- Where required reliable multicast service is supported between the CLANs
  - CLANs can be used as transit networks for multicast flows (and for unicast flows by extension)
- Mixed networks: ISDN, Internet, HF, 6-Bone, wireless LAN

# RED COALITION NETWORKS CONNECT ACROSS BLACK TRANSIT NETWORKS



# MAJOR RESULTS

- **Integration of building block technologies into global coalition network architecture**
  - **IPv4/IPv6, SNMP, IPSec, OSPF, BGP, DiffServ QoS, OLSR, MIPv6, OpenLDAP, Windows/Linux**
- **Dynamic routing with OSPF**
  - **Dynamic network topology**
  - **Avoids full mesh of security associations**
  - **Multicasting**
- **VPNs with tunneling across transit networks**
- **End-to-End QoS**
  - **DiffServ for multiple service classes, scalability and security**
  - **DSCP across ICDs (IP Crypto Devices)**
- **Mobile networks and wireless edge devices**
  - **OLSRv6 MANET**
  - **MIPv6**


# TESTING AND DEMONSTRATIONS

- Internetworking of IPv6 applications running on Windows and Linux
- View of coalition VPN status by coalition network manager
- National control over extent of configuration changes exercisable by coalition network manager using SNMPv3
- Interoperation of FreeS/WAN and 6Wind IPSec devices
- Multicasting over the coalition VPN containing unicast secure tunnels
- Dynamic routing with nested tunnels across the VPN
- End-to-end QoS DiffServ over red and black domains
- Dynamic MANET/WAN gateway discovery
- MANET technology support for attached networks on mobile platforms (e.g. ships, tanks)
- Interoperation of MIPv6 and MANET mobile routing protocols
- Robust directory service with distributed DNS

# SOME TECHNICAL ADVANCES

- Distributed network management of CLANs with IPv4 SNMPc for management information transfer via v4/v6 tunnels across WANs
- First prototype implementation of IPv6 IPSec for FreeS/WAN Linux
- IPSec header compression for narrowband military networks
- First prototype implementation of IPv6 OLSR MANET routing protocol
- New MIPv6 and OLSR routing extensions for joint MIPv6/OLSR use
- Robust directory service with distributed DNS servers in the red/black domains and automated replication of DNS entries
- Robust PKI with OpenLDAP repository service for replication of security certificates and revocation lists

# AVENUES FOR TECHNOLOGY ADOPTION


- NATO OPLANS/Ops
- NATO STANAGs
- Field Demonstrations
  e.g. Joint Warrior Interoperability Demonstrations
- National Systems and Networks
- Technical Symposium

# TRANSITION ACTIVITIES

- France
  - MoD policy mandates dual-stack IPv4/IPv6 in all new developments and acquisitions
  - Plans for evolving existing networks and applications to IPv6 under investigation
- Germany
  - MoD policy mandates IPv6-based communications for network operations
  - Applying results in security, QoS, routing, and mobility to tactical networks
- NATO
  - Recognizes need to consider evolving the NATO WAN from IPv4 to IPv6
  - Exploiting results in network architecture, naming and addressing, routing, QoS, and directory service
  - Directory service adopted by Air Force C2 operations at The Hague, NL
- United Kingdom
  - Adapting results in system architecture, routing, QoS, and mobility to the MoD Global Information Infrastructure,
  - Moving to develop strategies and policy for IPv6
- United States
  - Navy ADNS (Automated Digital Network System) deploying IPv4/IPv6 Cisco routers and acquiring IPv6 addresses for the afloat Navy
  - Mobility technology transitions to IETF MANET Working Group, Navy ADNS, and Joint Service JTRS

# FUTURE PLANS

**To develop/test enhancements to building-block technologies to meet more directly coalition network needs.**

- **Security: additional security mechanisms**
  - **Reliable multicast for IPSec**
  - **Tactical PKI applicable to coalition networks**
  - **IPSec discovery protocol suited for large, dynamic coalition networks**
- **Mobility: enhanced MIPv6 and MANET for coalition operations**
  - **Access control and auto-configuration**
  - **MANET multicasting**
- **Network and Traffic Management**
  - **management across multiple security domains with mobile networks**
  - **policy-based management for end-to-end QoS**
  - **dynamic SLAs (Service Level Agreements)**
  - **Mobile ad-hoc networks**
- **Wide Area Networks and IPv4/IPv6 Inter-working**
  - **Develop improved WANs for test program**
  - **Integration of SATCOM with DVB (Digital Video Broadcasts)**
  - **Support IPv4 applications over IPv6 network with network address translators and application level gateways**

**Work is planned to continue through Spring 2006.**

# SUMMARY AND CONCLUSIONS

**Pioneering investigation into technical/architectural issues in migrating from IPv4 to IPv6 in a military context, substantiated with tests and demonstrations in support of coalition operations**

- **Built and tested a secure, global, coalition, IP network as a VPN over a mixture of IPv4/IPv6 networks and technologies**
- **Demonstrated the maturity and interoperability of IPv6 routing protocols**
- **Achieved end-to-end QoS routing across diverse networks and two separate security domains**
- **Transition activities underway in NATO nations**
- **Work continuing to develop enhanced building-block technologies for coalition networks**
- **Coalition interoperability R&D beyond capabilities of any one nation**

**More information available on the Web at http://insc.nodeca.mil.no**