Global Information Grid Evaluation Facilities

... Building tomorrows scalable Transformational Communications Architecture (TCA) today!

Provides inter-network demonstration and validation
TSAT, GIGBE, JTRS, Teleports, ARMY, Navy-Marines, Air Force, NASA, Intelligence Community ... IPV6/MPLS
GIG-EF Philosophy …

• Interconnect Architects, Developers, Users and Testers of the GIG
• Guided by Acquisition Components yet remain **Objective**
• **Stress-Test/Evaluate** GIG Components in Collaborative Environment

**ANALOGY:** Like the Jet Engine Test Stand…

• Provide support to systems, but not the systems themselves
• The “Test Stand” must be a strong framework and not budge when the systems are “run up to 120% of full thrust”
• Connect the “parts” under test and provide the “fuel” (data flows)
• Instrument all components to reveal the performance of the “parts” and their failure modes
“Expose interfaces early and often”

- Provides scalable, E2E net-centric operation
- Integrated standards-based services
- Robust, adaptable, dynamic and flexible operation
- Interoperable data capture; integrated ops centers
- Accommodates multiple levels of security E2E
- ”Black Core” source encryption
- Enables new information exploitation processes
- Transformational, global ISR

Bandwidth x Low Latency\(^{-1}\) = Professionalism

... VAdm (Ret) J Cebrowski
Provides inter-network demonstration and validation

... A Place to Test Early and to Test Often ! ! !
IPV6/MPLS End-to-End Testbed

GOAL: Provide users Secure Stable Global Data Access

- IPV6/MPLS Latest Commercial Features
- Efficient Routing ... ISIS, BGP+, OSPF, GMPLS
  - Satellite/Fiber/Wireless/Mobile Services
  - RF or Optical Transport
- Full Range of Quality-of-Service Features E2E
  - Priority, Pre-emption, Policy, Authorization, Audit
  - Voice, Video, Data w/ SIP Control Plane
- Scalable Speeds: Bits/sec to 10Gbps initially, 40Gbps, 160Gbps
  - Data is doubling every year
- Network Test and Measurement Capabilities
  - Know the “State of the Network” Dynamically
  - Complete Passive Monitoring with Accurate Time-stamping
  - Stress to “Future Military Operational Levels”
- Conduct “R&D” to Help Resolve Problems/Issues

Scaling to 100,000’s Users Supporting TPPU & TPED
Transition IPV4/MPLS -> IPV6/MPLS
... BGP4, OSPF, SIP, etc ...

Phase I: IPV6 Initial Build

DRENB(HPCMP) Network

GIG Testbed OOO Network

IPV6/MPLS Instrumented Testbed ...
RIPng, IS-IS, BGP+
Dual Stack: IPV4 w/ BGP4, OSPF
Research platform for 10-40G
BOSSNET
MIT/Lincoln Labs
Simple Queries Trigger Extensive Bandwidth Utilization

TPPU Bandwidth Amplification

SuperCs

Sensors

Teleports

JTRS, Wireless, Mobile, etc …

Large Numbers of Lite-Clients
E2E IP User Services...

- IPv6, XML: JTRS, GigBE, TC, Teleports, legacy
- QoS, COS for UBR, VBR, CBR
- Access, Authenticate, Audit
- Policy Enforcement
- Priority and Pre-emption

SIP-based Policy & Directory Server:
- Operates on Session Request from Clients
- Performs Authentication
- Determines Location of Requested Services
- Initiates Network setup with appropriate Policies

SIP Client Protocol:
- Authenticate & Login
- Request Service and Connectivity
- One Control protocol

SIP-based Clients:
- SIP Allows **Profile Portability**
- Range from Phones - Video - Teleconference - WS - Servers - SC
- Make Request of Services, Peer Connectivity, and Network Connectivity

Network Signaling: Proxy Server Operates on SIP Server commands
- Initiates on Transport Network Signaling
Network Growth Trend . . .

### Network Research Agenda

<table>
<thead>
<tr>
<th></th>
<th>TODAY 2005</th>
<th>0-2 YEARS</th>
<th>3-5 YEARS</th>
<th>5-15 YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OPTICAL STREAMS</strong></td>
<td>1-10 Gbps</td>
<td>10-40 Gbps</td>
<td>100-640 Gbps</td>
<td>1-10 Tbps</td>
</tr>
<tr>
<td><strong>OPTICAL CNTL Plane</strong></td>
<td>STATIC Provisioned</td>
<td>DYNAMIC (GMPLS)</td>
<td>JIT Just-in-time</td>
<td></td>
</tr>
<tr>
<td><strong>IP CNTL Plane</strong></td>
<td>STATIC Tunneled</td>
<td>DYNAMIC SIP</td>
<td>SIP</td>
<td></td>
</tr>
<tr>
<td><strong>LAN Technology</strong></td>
<td>IPV4: 1GE, OC12c, 4xInfbnd</td>
<td>IPV6: 4x/12x DDR Infbnd, 10GE</td>
<td>IPV6: 12x QDR Infbnd, 100GE</td>
<td></td>
</tr>
<tr>
<td><strong>SECURITY Devices</strong></td>
<td>1.0G IPV4 Firewalls, CBs, KGs</td>
<td>10G KGs, HAIPEs, FEON, NTAM</td>
<td>40G HAIPE, GFP Encptr</td>
<td>640G HAIPE, GFP Encptr</td>
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<tr>
<td><strong>SPECIAL TOPICS</strong></td>
<td>Quantum Key Distribution (QKD), Dynamic PMD Comp, Peering, OOO(2R) Optical Regeneration</td>
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- **JIT**: Just-in-time
- **QKD**: Quantum Key Distribution
- **PMD Comp**: Permanent Multiplexing Daughter Comp
- **OOO(2R)**: Optical Out-of-Order (2R) Regeneration
ViPr: Video Presence Flexible Audio/Video Teleconferencing

... IPV6 based, SIP Control Plane, 14+1 Participants, “White Board” enabled, clear progressive HD video, echo-cancelled audio, touch controlled
Passive Monitoring Strategy …

DAGMON IP Packet Monitoring
NTAM: Network Transaction Activity Monitor
Authentication/Security …
  • Non-obtrusive
  • GPS sync … PPS timestamp integrity
  • E2E Network Packet Delay and Jitter
  • Bandwidth & Timing Measurements
  • QoS Monitoring/Measurement
  • SLA Verifications (CoS)
  • Synchronized Multi-site Traffic Recording
  • NTAM E2E Flow Monitoring/ Measurement
    • E2E Performance Analysis
    • Enhanced Information Assurance
    • Security Policy Enforcement

“Gargoyles”
Active Loading/Stress Testing …

**IXIA Test Gear & Net IQ Chariot** …
- Hostile traffic generation: TCP/RTP/UDP
- Proactive performance
- Error injection, E2E jitter, delay, loss, BERT, sequence
- Differentiated services
- Routing protocols …
  - IS-IS, MPLS(RSVP-TE, LDP), RIP, OSPF, BGP4, IPV6 RIPing, IPV6 IS-IS, IPV6 BGP+
- ERP, XML web, ftp traffic
- Videoconferencing w/ IP Multicast
- VoIP Mean Opinion Scores
- QoS verification, COS verification
A User Services Net-Centric Perspective

- Volume of Information Increasing Exponentially
- Demand for Net-Centric Services Increasing Exponentially

**PROBLEM:** DELIVERY TIME INCREASING FROM HOURS TO DAYS

**LARGE DATA:** SIGNIFICANT INCREASE IN BANDWIDTH WITH HIGH END-TO-END QUALITY OF SERVICE (QoS/QoP) - REDUCE DELIVERY TIME TO SECONDS OR MINUTES: ...REACHBACK!

“THE TIMELY DELIVERY OF IMAGERY, VIDEO, AND LARGE DATA FILES IS A HIGH VOLUME INFORMATION DISSEMINATION REQUIREMENT THAT DEMANDS A SOLUTION”

AIR FORCE SPACE COMMAND

Sources: Advanced Media Networks Technology Briefing, And DTIC Website
IMAGERY EXAMPLE: Geospatial Knowledge Base (GKB) and Very Large Data Base (VLDB)

... Organize all Geospatial Knowledge to support Analysts, Warfighters, and other Consumers

... Semantic Web Based .geo

**PROBLEM:** REQUIRES ADVANCED STORAGE (RAIN) and A NETCENTRIC HIGH PERFORMANCE, LOW LATENCY ARCHITECTURE

**LARGE DATA ACTD:** TECHNOLOGIES THAT PROVIDE DISTRIBUTED, SYNCHRONIZED, HUGE DATA STORES SCALABLE TO EXABYTES (over $10^{18}$ bytes): TRACEBACK

MUST BE ABLE TO FULLY ARCHIVE ALL DATA AND HAVE ONLINE ACCESS TO ARCHIVES FOR REAL-TIME PLANNING AND ANALYSIS
LARGE DATA ACTD SOLVES A DOD WIDE PROBLEM

FEDERATED, DISTRIBUTED NET-CENTRIC INFRASTRUCTURE A KEY ENABLING TECHNOLOGY
“LARGE DATA” APPLICATION CHALLENGE:
Reduce Latency to Post, Access and Analyze Very Large Data Sets: Imagery, Video, MASint, SIGint, etc…

- Current operational systems … 2-3+ days may be required to Access, Transfer, Process, and Analyze “BiG Data” sets (TPED)

Problems that use Big Data:
Example PACOM problem: BGen Cone “OIF” Lessons Learned --- “latency” is the issue, … (Currently hard to deal with Big Data across; local, distributed and archive storage/processing, distributed analysts… synchronization issues) … 5K x 5K clips

- Problem becomes increasingly difficult as data volumes increase significantly … solution requires move to “Network Centric” (TPPU)

Future Imagery Architectures, Higher Resolution Video (HDTV NGA mandate), 100x UAV’s, More MASINT Products, Multiple Distributed Analysts both in/out theater, realtime response… 40K x 40K clips
“Large Data” Challenge

... Transforming WWW for spatial-temporal post, access --- .geo

- Performance driven, wide area cache-coherent distributed SAN
- Realtime ingest of live data sources
- Multiple levels of resolution seamlessly manipulated (ZUI)
- Multiple collaborators … Situation Awareness … Big Picture
- Multi-INT data fusion
- Multiple levels of security
- Authenticated access to large amounts of distributed data
- Peer-peer interaction, spatial-temporal intelligent agents
- Analyst and Senior decision-maker … joint participation
- Akamai-on-steroids with RAIN(RAID)
- Online/Nearline disk archive, self-healing … 100’s TB per site
- No single point(s) failure, embedded data manager
- Data encrypted “at-rest”
- SIP control plane for MLPP
Possible TSAT Reference Scenario . . .

• Space-borne high-speed backbone using OBS-capable satellites
• Free-space DWDM ISLs with JIT signaling; no 3R regeneration required
• Real-time imaging UAV/Sensor; bursty due to changing coverage
• Two GEOs with 120° separation and 10 Gbit/sec transmission path

• ~ 210 msec ISL propagation delay
• ~ 120 msec UAV-to-satellite, satellite-to-ground propagation delay
• ~ 1 msec switching delay, < 1 msec processing delay
SC2004: IBWAN

A Fresh Start

OC192c <-> 4xIB

Infiniband RDMA
IBWAN Concept Board …

OC-192c Transmit & Receive Interface

10 Gbps InfiniBand Interface: 4xIB
InfiniBand (IB) Wide Area Networking
SuperComputing 2004

High-Speed Wide-Area Secure Peer-to-peer Distributed Computing Functionality envisioned by DoD/IC, NASA, DHS, DOE, etc.
• SuperComputer Services (as if) on your desktop
Demonstration of key Large Data ACTD high-speed wide-area features under NGA FY04 and NRL support:

- Initial proof of principle for High-Bandwidth IP Networks -- OC-192c (10Gbps)
- Simultaneous IPv6 (POS) and ATM *(UNCLASS, but supports Type 1 Encryption)*
- Long haul connectivity between Boston (MIT/LL), Baltimore (NSA LTS), Washington DC (NRL) and Pittsburgh (SC2004) (~1200km Boston to DC to Pittsburgh)
- Instant accessibility to large data no matter where it may be stored—just as if stored on your desktop
- Shows secure cache coherency and image-rich data from storage cluster

**World’s Largest Spatial INFINIBAND Network …**
• High-Speed Wide-Area Secure Peer-to-Peer
• Distributed, Federated Computing Functionality envisioned by DoD/IC, NASA, DHS, DOE, etc.
• SuperComputers (as if) on your desktop … ~ 6000km
**MOADB: Interactive Distributed Object Library**

- Virtual network of Active Information Producers & Consumers
  \( \text{... i.e., Grid core w/ P2P edges} \)
- Vertical fusion - aggregation, delegation
  \( \text{... i.e., level of detail} \)
- Horizontal fusion - peer group metadata search & discovery
  \( \text{... e.g., DoD Discovery Metadata Standard} \)
- Agile data - type support for spatiotemporal indexing
- Pluggable transport architecture including IPV6, native ATM & hardware QoS, DWDM
- Intelligent caching hierarchy for multi-terabyte/petabyte datasets (BIG DATA ...)

**Distributed Database Backend**

- Immersive Zoomable User Interface (ZUI)
- Filter and layer definition, selection, and presentation support
- Flexible, intuitive manipulation
- Platform support ranging from PDA to workstation to distributed grid to HPCS supercomputer
  \( \text{... High performance: SGI InfiniteReality & UltimateVision systems ... well defined API} \)
  \( \text{... Ubiquitous: Desktop PC/Mac/Linux, open source} \)
  \( \text{... Pervasive: iPAQ handheld} \)

**Visualization Front End**
Scalable Systems Port (SSP) Direct Access

MOACI: High Performance Functional Prototype Platform

Zero-copy Direct Access I/O (RDMA) ...i.e., 12x IB, SPI-5, Custom Demux, etc.
Scalable Optical Burst Switching with JIT Signaling

- No round-trip delay (for 2- or 3-way handshake) required prior to data burst
- Out-of-band signaling message precedes data burst
- A signaling message’s lead time over its data burst shrinks as both propagate through network
- Switch resources held only for the duration of burst; no light path required
- JIT simplicity - smaller, lighter hardware processing modules

- Significant improvement in throughput and determinism vs TCP/IP/GMPLS
- Out-of-band JIT signaling increases communications security and reliability
**JUMPSTART** Message Format

- Flexible IE (Information Element) based
- Separate hardware-parsable part (*Hop-by-Hop* significance) and software-parsable part (*End-to-End* significance)
- Will be used in all management protocols inside Jumpstart network (routing, fault management, etc.)

**JUMPSTART** Addressing

- Hierarchical
- Variable length (up to 2048 bits)
- Gives site administrators maximum flexibility in assigning addresses

**JUMPSTART** Forwarding

- Made easy by the address structure
- Each domain level has its own table
- A switch forwards a message by taking the longest match between own address and the destination address and using the appropriate table to forward the message
JITPAC Prototype Hardware
NRL JIT Installation . . .
Let’s Roll!