The Role of the Transport Layer in Delivering an Assured Elastic Service

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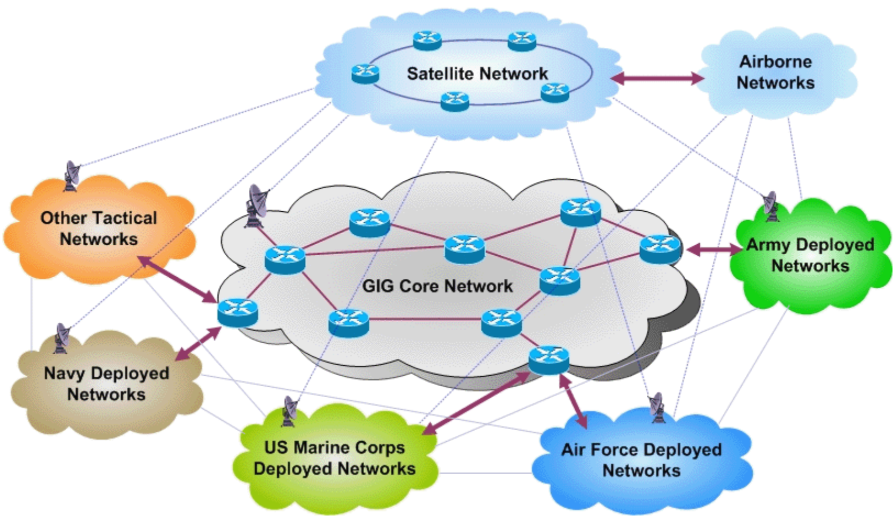
Outline

- Overview of the GIG
- Goals of today's talk
- Explanation of the GIG networking environment
- GIG Converged Services and the Assured Elastic Service
- Mechanisms to Support Precedence for Inelastic Traffic
- Behavioral Model and Functional Allocation for the Assured Elastic Service
- Summary and Suggestions

Background: Global Information Grid (GIG)

- The U.S. Department of Defense (DoD) is pursuing a transformation in communication infrastructure to enable any-to-any communication and improved information sharing across all GIG users and networks
- The vision is for the GIG to provide an Internet-like capability that meets the operational needs of multiple US Government agencies
  - Interconnects with civilian infrastructure at federal, state, and local levels
  - Interfaces with international networks, including NATO and coalition partners
- Component networks of the GIG include both:
  - Fixed & Mobile Assets
  - Ground, Air & Space Assets
- The GIG technical community is working on designing an interoperable architecture and protocols across all of these disparate networks



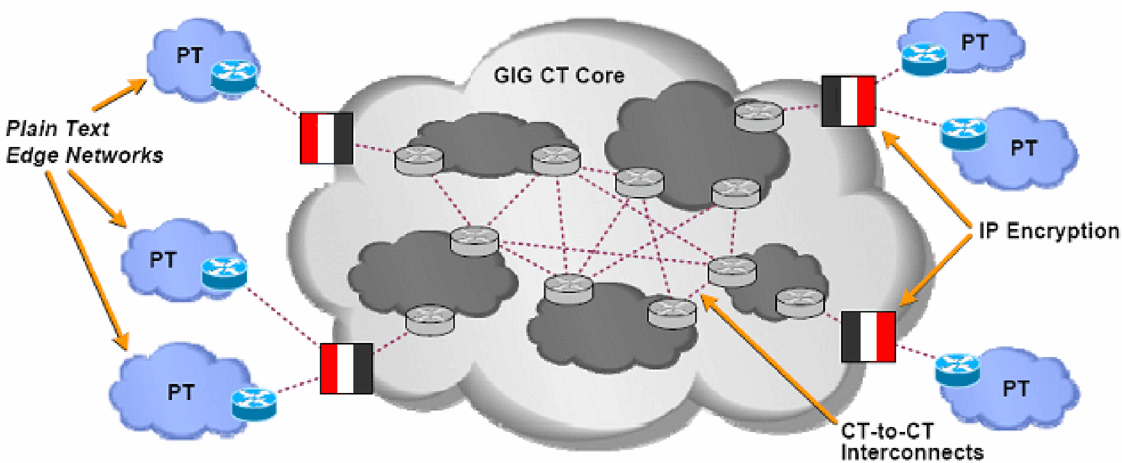
High-Level View of the Global Information Grid

Goals of Today's Talk

- It is our aim to adopt existing open standards while encouraging development of standards and technology to support our infrastructure requirements
- Today's talk is aimed at introducing the GIG problem space as it relates to Congestion Control as well as describing our current technical approach
- In doing so, we solicit your feedback on the following questions as they relate to the transport layer and congestion control:
  - **What congestion control mechanisms can satisfy the elastic application performance requirements over a wide range of networking environments?**
  - **How can the transport layer contribute to delivery of the Preferred Elastic service? What is the functional allocation between network nodes and end hosts in providing this service?**
  - **What is the role of congestion control, and the transport layer in particular, in satisfying the precedence requirements for elastic traffic?**
  - **What distinguishes Preferred Elastic from the Default Service? Specifically, are there distinctions with regard to congestion control and other mechanisms at the transport layer?**

GIG Cipher Text (CT) Core / Plain Text (PT) Edge Networks

- The GIG includes the GIG CT Core surrounded by PT Edge Networks
- The GIG IP topology is divided into sections based on the nature of the user traffic carried in that part of the network
    - Plain-text (PT) network - user traffic is not IP encrypted
    - Cipher-text (CT) network - user traffic is IP encrypted
- A PT network is connected to a CT network via IPsec (tunnel mode) gateway(s)
- PT networks are grouped into different Communities of Interests (COIs); PT-PT communication is permitted within a COI
- This PT/CT separation separates the GIG address space and limits data, control and management plane information exchange across the PT-CT interface



Objective End-to-End Global Information Grid Infrastructure

GIG Network Types

- This GIG is composed of several networks exhibiting a range of capabilities characterized in terms of:
  - Bandwidth, Size, Weight and Power (SWaP), node mobility, and link reliability
- Networks operating in the fixed environment share many properties of today's Internet
  - Most networks will be stationary or will remain within a single hop of the fixed infrastructure
  - Over-provisioning of subscriber links
- Networks operating in the tactical environment are subject to node mobility and challenging link characteristics
  - Ad-hoc connectivity
  - RF-based, high-latency links
  - SWaP constraints
  - Subject to topology changes over time
  - Reachability to/from fixed infrastructure may be intermittent

GIG Fixed Networks

- Fixed or stationary nodes/Stable network topology
- IP-capable/Highly reliable links/high bandwidth
- Not severely constrained by SWaP
- High level of physical security protection

GIG Advantaged Tactical Networks

- Mostly stationary nodes
- Reliable links, approaching "highly reliable"
- IP-capable/mostly stable network topology
- Moderate bandwidth/Not severely constrained by SWaP
- Moderate level of physical security protection

GIG Disadvantaged Tactical Networks

- All or mostly mobile nodes/Least reliable links
- High latency communications
- Not all end-hosts and networks are IP-capable
- Least stable network topology (highly dynamic)
- Bandwidth constrained, constrained by SWaP
- Low level of physical security protection

GIG Converged Services and Precedence

- The GIG will support and control the usage of multiple traffic types over the same infrastructure
  - Inelastic/Real-Time Traffic
  - Elastic
- Precedence is defined as the user designated importance of an application session
  - Long been defined for circuit switched voice
  - Policy is being revised and extended to address IP voice, other real-time traffic, and (eventually) elastic traffic
- ***The second half of this briefing focuses on implementing the Assured Elastic Service***

Categories	***Service Class***
Network Control	Network Control
Real-Time	Telephony
	Signaling
	MM Conferencing
	Real-Time Interactive
	Broadcast Video
Assured Elastic	MM Streaming
	Low-Latency Data
	OAM
	High Throughput Data
Default Elastic	Elastic

Mechanisms to Support QoS

- The GIG has adopted data plane, control plane, and application layer control mechanisms in providing QoS to end hosts
  - Data Plane- Implementation of Per Hop Behavior (PHBs): a description of the externally observable forwarding behavior of a node
  - Control Plane- Network Admission Control allows applications to request resources from the network. The network responds by explicitly admitting/rejecting QoS requests.
  - Application Layer Signaling- application layer control protocols that can establish, modify, and terminate multimedia sessions (conferences) such as Internet telephony calls
  - Management Plane: management systems play a role in planning, configuring, monitoring, and auditing this service

Precedence Support for Assured Inelastic Service

- Real-time inelastic applications such as voice and video have well-defined mechanisms and protocols available (e.g., EF PHB, RSVP, SIP)
  – Can ensure resources and mechanisms within the network will adequately support application requirements
  – Can help meet the precedence requirements through control plane, application layer, and management plane mechanisms

- ***Are similar approaches applicable in providing a Assured Elastic Service?***

Behavioral Model for an Assured Elastic Service

- For inelastic traffic, a behavioral model to provide "Assured Inelastic Service" is fairly well understood
- For the assured elastic service, the behavioral model described in RFC 1633 and elsewhere will need to be extended
  - Service Model for different elastic application types allows for different delays for interactive burst, interactive bulk, and asynchronous bulk applications
  - The behavioral model for Assured Elastic will need to allow for improved throughput for higher precedence traffic
    - For example, low precedence application sessions will experience lower average throughput than higher precedence
    - However, this raises several questions, such as is there the equivalent of a "call blocking probability" for elastic application sessions? If there is a relative service for Assured Elastic, how "relative" should it be?
  - We anticipate an expanded role for planning and management in offering the Assured Elastic Service
- Given its relative immaturity, this technical area remains a work in progress

Current Approach to the Assured Elastic Service

- The GIG technical community has focused on the requirements of the network in providing the Assured Elastic Service
  - We have not described the role of the Transport Layer in providing this service

- The current baseline has defined separate service classes for high precedence traffic and low precedence traffic

- For higher precedence traffic, our current architecture suggests the use of differential drop probabilities with the intention of providing further granularity

- However, debate continues; the use of differential drop probabilities may not provide the service that is required

Implementing the Assured Elastic Service

- Requirements for the Assured Elastic Service and the work to date raise several questions
- How is this Assured Elastic Service differentiated from a Default Service at end hosts? In the network?
- What are the responsibilities of the transport layer in satisfying our Precedence requirements?
- How does the transport layer interface with the application to provide Assured Elastic Services? With the Network?

The Role of the Transport Layer: Performance Challenges

- The GIG's reliance on long-delay, satellite networks will constrain the performance of transport layer protocols; Our networks also employ links and topologies that introduce additional challenges
  - Intermittent Links with varying BW
  - Mobile/Dynamic Topologies with asymmetric and variable paths
- PEPs/middleboxes have been deployed to improve TCP performance over satellite links and may suffice as a short-term solution
  - Difficult to implement in a shared, CT based infrastructure
  - Not traditionally used in networks with dynamic topologies
- In the research community, much work has been conducted in enhancing transport layer performance for each of these environments

- ***We require a solution that can control congestion over an infrastructure incorporating <u>all</u> of these environments while providing preferential treatment of higher precedence traffic***

The Role of the Transport Layer: Precedence

- Different categories of Congestion Control mechanisms have been proposed to improve performance

Performance Enhancement Approach	Examples
End-Host Upgrade	• TCP NewReno • F-RTO Recovery • Increasing TCPs Initial Window • Selective Acknowledgement (SACK) • High-Speed TCP (HS-TCP)
End-Host and Network Upgrade	• Quickstart for TCP • eXplicit Congestion Protocol (XCP) • Explicit Congestion Notification (ECN)

- Should these or other Transport Layer mechanisms be extended to support Precedence?

Functional Allocation to Support Precedence

- Various models could be proposed to support a Precedence Based Assured Elastic Service, for example:
  - <u>Transport Layer is precedence aware</u>: The Network treats all elastic traffic similarly. Higher Precedence sessions react differently to congestion than lower precedence sessions
  - <u>Transport Layer is not precedence aware/network differentiates:</u> The network forwards the Assured Elastic traffic in one Service Class; the Elastic Traffic in another
  - <u>Transport Layer and Network are precedence aware while incorporating a direct interface between the Transport Layer and the Network</u> : The transport layer and the network directly communicate regarding the precedence level of the sessions as well as the availability of resources
  - Additionally, what is the role of the control plane in providing an Assured Elastic Service?

- What is the right functional allocation? Perhaps the WG could help shed light on this discussion?

Summary and Suggestions

- DoD intends to implement the RFC 4594 service classes in the GIG, including Assured Elastic
  - DoD may require differentiation of elastic traffic according to military precedence
  - In either case, it remains an important goal and design objective to (be able to) leverage new commercial technology as it emerges and becomes standardized
- We seek a broad view of Assured Elastic implementation that enables the transport layer and congestion control to play a major role
- We are interested in contributing to the ICCRG Problem Statement drafts
- We also seek feedback on how to avoid limiting or inhibiting the use of future congestion control mechanisms in the course of implementing the Assured Elastic service