Extending Net-Centric Quality of Service to Systems of Systems

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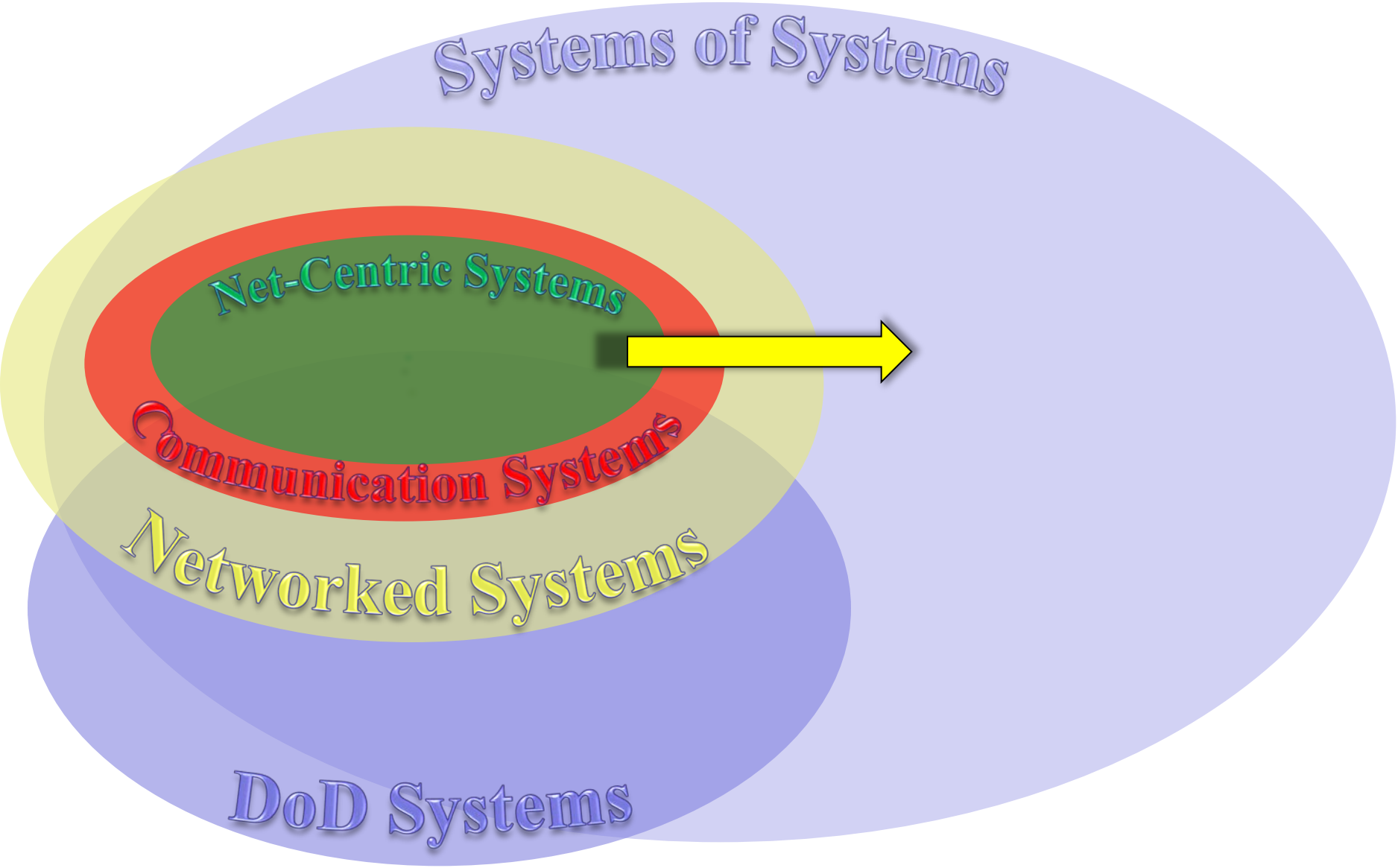
Outline

Offer an alternative perspective to viewing interactions within systems of systems based upon a net-centric quality of service framework.

- Quality of Service (QoS)
- Systems of Systems (SoS) Abstract
- QoS in Net-Centric Systems
- Key QoS Features
- QoS in Generalized SoS
- Improving the SoS
- SoS Necessities
- Systems Engineer Perspective
- QoS Construct for the SoS

QoS for SoS


Systems of Systems
Net-Centric Systems
Communication Systems
Networked Systems
DoD Systems

Quality of Service

- Resource reservations
- Priority for apps, users, data flows
- Specific performance
- vs. best-effort and over-provisioning
- Service Level Agreement (SLA)
- Monitored, maintained, managed
  - QoS may refer to the measure
  - Intserv – per flow (RSVP)
  - Diffserv – per class (DSCP)
  - Traffic Shaping and Scheduling techniques
- Device capability
- Service-Oriented Architecture (SOA) view

Quality of Service Key Parameters

- Resource Reservation
- How Signaling Transferred
- Coupling with Routing/Forwarding Method
- State of Resource Management
- Required Participation

QoS Key Parameters Example (1 of 2)

RSVP: - reservation-based QoS protocol
- based on integrated services (INTSERV) model

Key Feature	Implementation
Resource Reservation	Class • best-effort • rate-sensitive • delay sensitive Assignment • distinct (per flow) • shared (group)
How Signaling Transferred	Messages • reservation-request • path • error/confirm • teardown Communicants • host-to-router • router-to-router Maintenance • refreshed • times out

http://www.cisco.com/en/US/docs/internetworking/technology/handbook/RSVP.html

QoS Key Parameters Example (2 of 2)

RSVP: - reservation-based QoS protocol
- based on integrated services (INTSERV) model

Key Feature	Implementation
Routing Coupling	Routing Independent
Resource Management State	Soft in all nodes
Required Participation	Clusters – tunneling possible

http://www.cisco.com/en/US/docs/internetworking/technology/handbook/RSVP.html

Origins and Directions

- SERVQUAL: - developed by Zeithaml, Parasuraman, Berry
  - measure how service organizations meet customer needs
- QoS: maintaining circuit-switched telephony – transitioned to IP QoS.
- QoE: user perception of product quality and utility.

Service Quality SERVQUAL	Quality of Service QoS	Quality of Experience QoE
▪ Tangibles ▪ Reliability ▪ Responsiveness ▪ Competence ▪ Courtesy ▪ Credibility ▪ Feel Secure ▪ Access ▪ Communication ▪ Understanding the Customer	▪ Delay ▪ Jitter ▪ Dropped Packet Rate ▪ Packet Error Rate ▪ Throughput	▪ Usefulness ▪ Happiness ▪ Satisfaction ▪ Worthwhile ▪ Expected

System of Systems

a set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities [Defense Acquisition Guidebook Ch. 4 “System of Systems Engineering"]

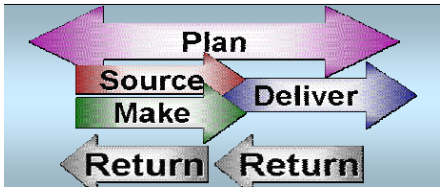
- Characteristics
  - Operational Independence SOA QoS
  - Managerial independence SOA QoS
  - Evolutionary development SOA QoS
  - Emergent behavior SOA QoS
  - Geographic distribution SOA QoS
- Control [Maier 1998]
  - Directed
  - Collaborative
  - Virtual
  - Acknowledged
- Examples
  - Aerospace Operations Center (AOC)
  - Air Traffic Control Systems
  - Public Utilities
  - Supply Chains

System of Systems

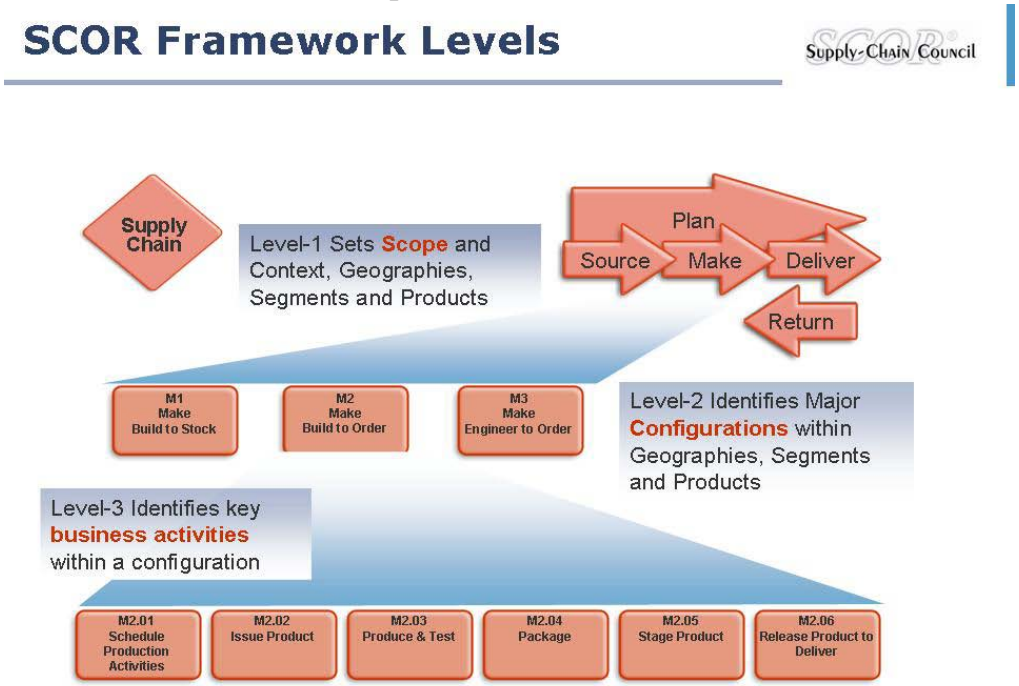
- Architecture
- Evolution and complexity
- Evolutionary architectures require: [Selberg & Austin, INCOSE 2008]
  - Standard interfaces
  - Interface layers
  - Continual system verification and validation
- Self-organized SoS [Bak Tang Wiesenfeld 1987]
- SoS may grow scale-free [Albert Jeong Barabasi 2000]
  - Hierarchical
  - Non-exclusive interdependencies
  - Fault tolerant

Supply Chain as a SoS

- DoD Supply Chain as a System of Systems [LTG Christianson (J-4) 26Jul06]
  - Objective: Timely & Precise Response
    - Speed
    - Reliability
    - Visibility
    - Efficiency
    - Performance Tracking
    - Process Diagnosis



  - Independent Players: Same Team, Dispersed, Complex, Resource Pressures
- Supply Chain Reference Model (SCOR) – Supply Chain Council
  - sequencing
  - elements of functional decomposition



Value of QoS for Net-Centric Systems

- Timely Data
- Design Service Levels
  - Specific Applications
  - Specific Users
  - Classes
- Designate and Maintain
  - Command and Control
  - Communications
- Preserve Scarce Resources
- Enable Cloud-Computing and SOA-Type Processes
  - Reduced forward footprint and resources
  - Centralized storage/processing
  - Minimize secondary methods
- Requirements
  - Efficient Routing
  - Control Signaling
  - Message Marking
  - Admission Policy
  - Admission Control

Key Features Delivered by QoS

Reliability

Accessibility

Timeliness

Scalability

Customizability

Durability

Availability

Portability

Evolvability

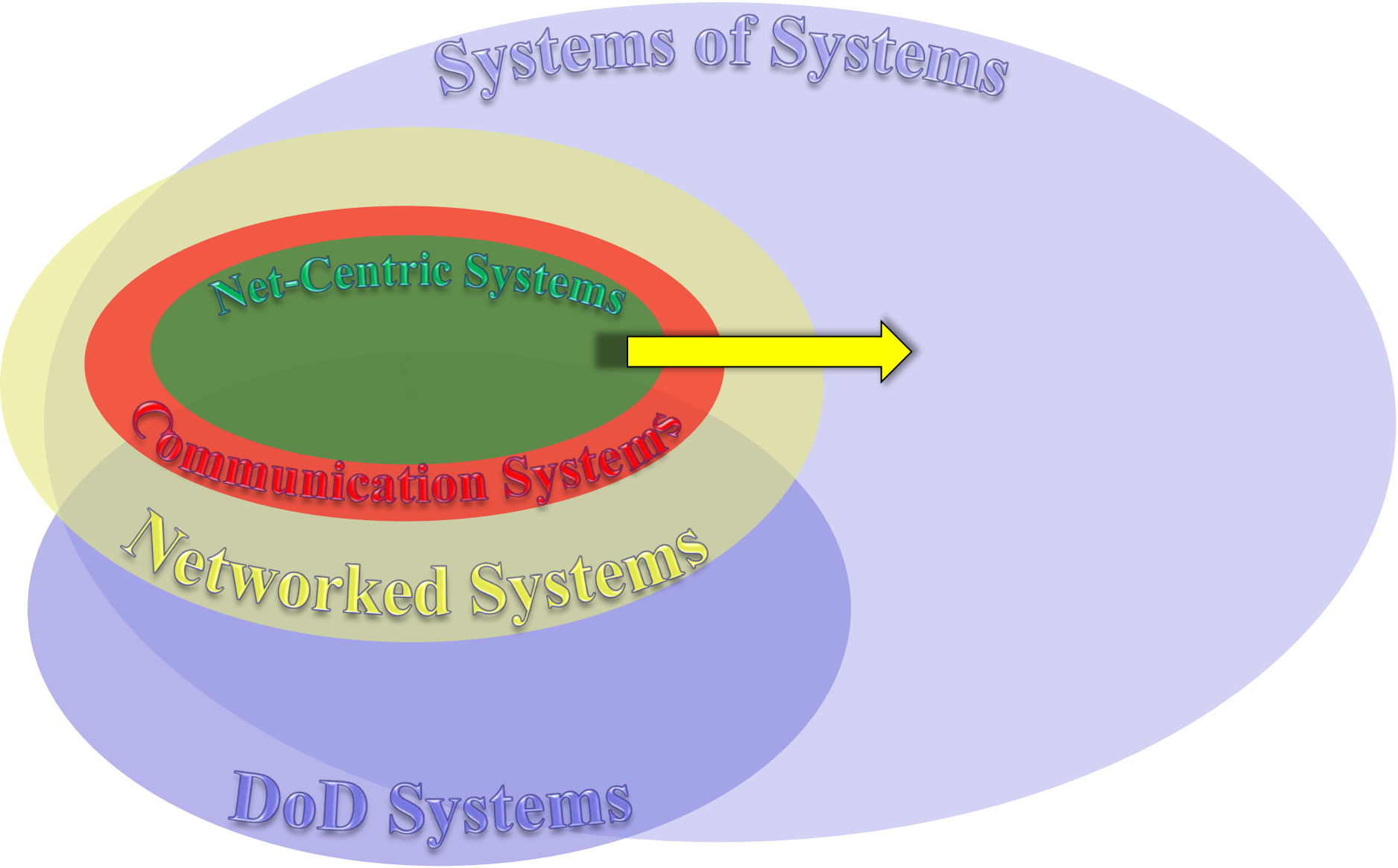
Extensibility

Interoperability

Survivability

Distributability

QoS for SoS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QoS in a Generalized SoS

Key Feature	Implementation	Discussion
Resource Reservation	Priority, responsiveness, quality, detail, precision… distinct or shared	Heavily Application Dependent
How Signaling Transferred	• request-for-bids, RFP, proposal, contract, kickoff, reviews, wrapup • non-disclosure-agreement • advertisement, menu, subscription, publish, instructions, terminate	contract, PO, warranty, maintenance SLA, contract, PO, warranty, maintenance
Routing Coupling	Closely or loosely coupled	CBD, sub-contract, invitation to bid
Resource Management State	Soft or Hard one, some or none	IDIQ or FFP/pre-paid
Required Participation	Clusters – tunneling possible	Agreements form communities

Improvements to the SoS

- Managing with greater fidelity
  - Own resources
  - Promises
- Systems leverage other systems
  - Reliability
  - Confidence
  - Risk
- Layered management of complexity
  - Framework
  - Emergence
  - Guarantees
- Outsourcing and core expertise
  - High cohesion
  - Purpose
  - Modularity (low coupling)

Requirements for QoS in SoS

Requirements for QoS in Net-Centric SoS

- Efficient Routing
- Control Signaling
- Message Marking
- Admission Policy
- Admission Control

Similarly…

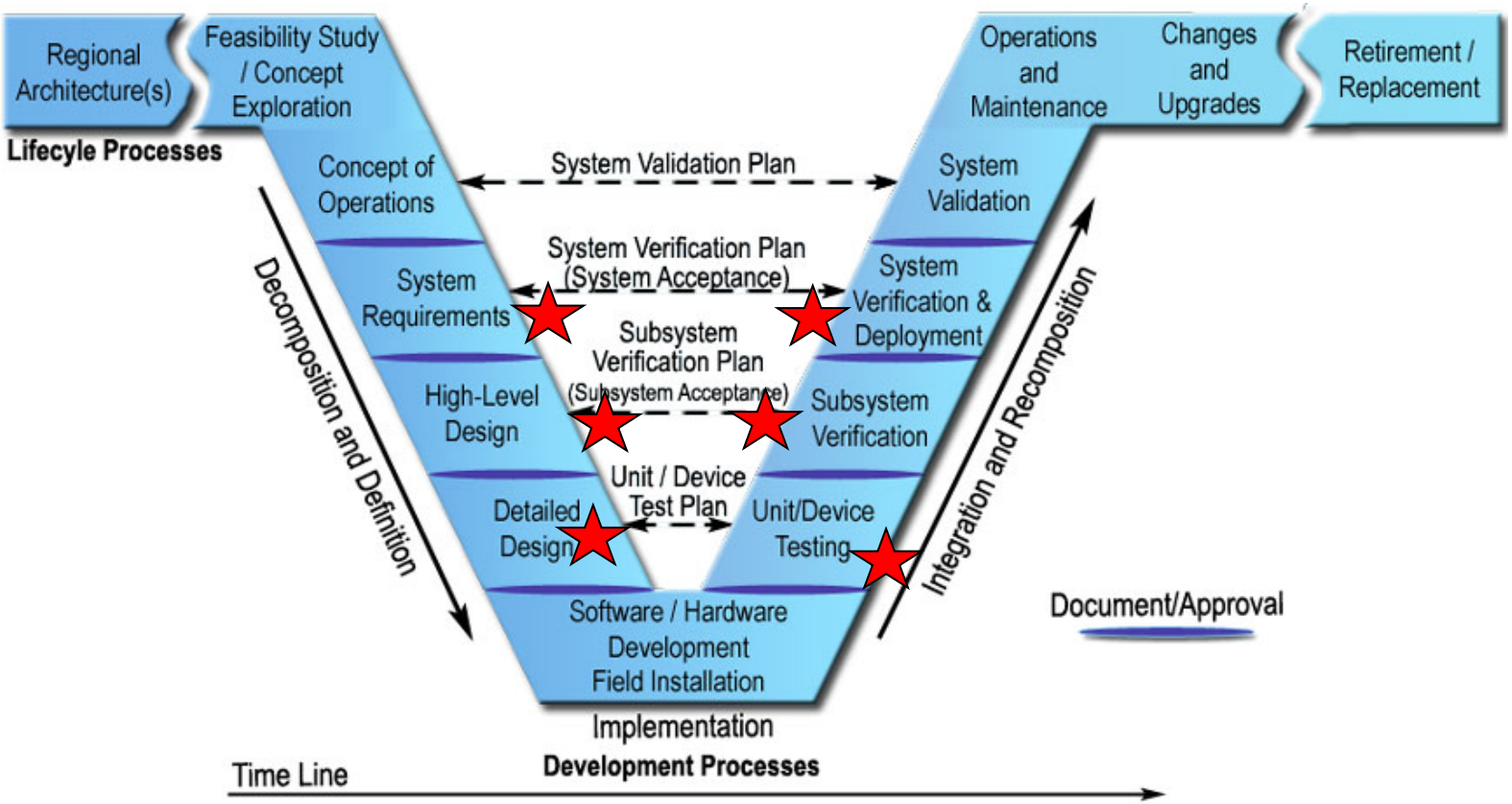
- Efficient product delivery
- Vehicles
  - initiate
  - terminate
  - adjust
  - modify
- Labeling (ID and Priority)
- Admission criteria
- Triage at each node

QoS for SoS vs SERVQUAL

- SERVQUAL measured organization performance relative to customer needs
- QoS
  - Establish contract
  - Maintain commensurate flows
  - Means to adjust flows
- Automation in SoS
  - More common today
  - Measurement and control common
  - Feedback possible
- QoS for SoS requires
  - Documenting requirements
  - Monitor requirements fulfillment
  - Intermediates: divide and apply resources

Systems Engineering Motivation

- SoS Design and Build difficult undertaking
- QoS: critical and responsive
- QoS for SoS in “V” highlighted★



Systems Engineering Motivation

System Engineering for System of Systems: Core Elements

- Translating Capability Objectives
- Understanding Systems and Relationships
- Assessing Performance to Capability Objectives
- Developing and Evolving an SoS Architecture
- Monitoring and Assessing Changes
- Addressing Requirements and Solution Options
- Orchestrating Upgrades to SoS

- Systems Engineering Guide for Systems of Systems 2008

Summary

- The Quality of Service (QoS) framework has promise to aid in design and operation of a System of System (SoS) which must allocate scarce resources.
- The SoS must include certain basic elements to gain from a QoS framework.
- SoS using a Service Oriented Architecture (SOA) are most compatible--any SoS may adopt the framework.

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