Scale-Free Command & Control

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Outline

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- Scale Related to C2 Policy Domains
- Federated Systems of C2 Systems
- C2 System Actor Model
- Scalable C2 Controllers
- Scalable C2 Application Services
- C2 Completion-Time Semantics
- C2 Controller Operations

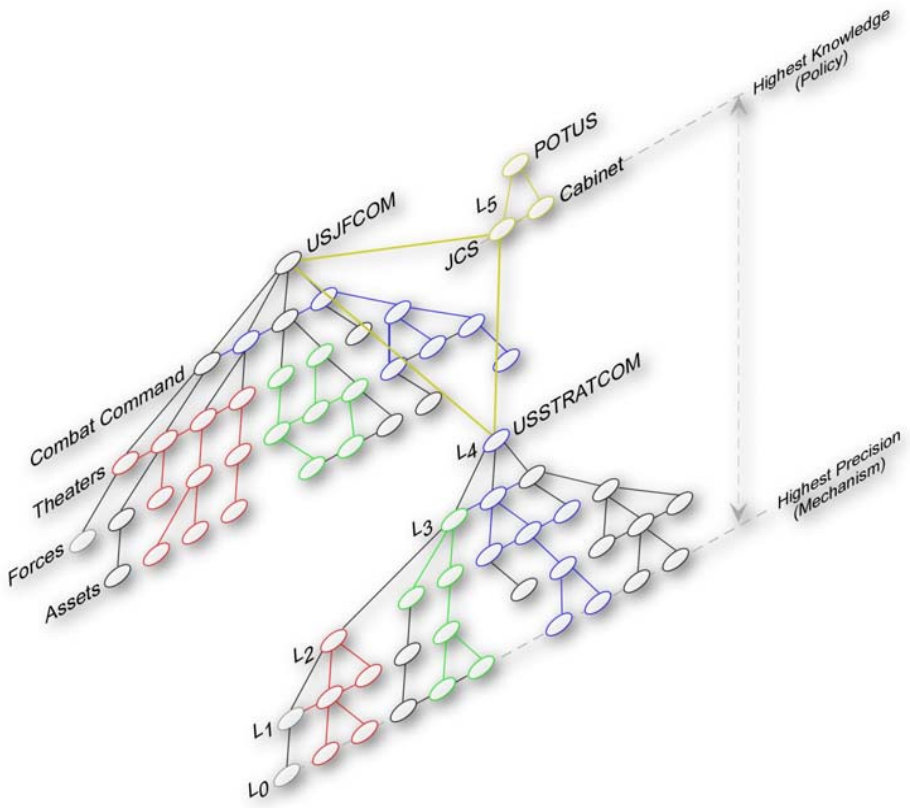
Thesis

- Network centricity *empowers* everyone, from POTUS to soldiers at the edge, regardless of rank or service allegiance
- Enlightened, continuous, fast paced and distributed decision making requires *trust* at all levels in support of collaboration, interoperability, and "jointness"
- Trust implies intra- and inter-service *discipline, accountability* and *adaptability*
- Discipline requires *formal*, *reproducible* and *traceable* (i.e., causal) *policies* and *processes*

⇒ We require a core set of scalable ("scale-free") services supporting time-bound collaborative, distributed C2

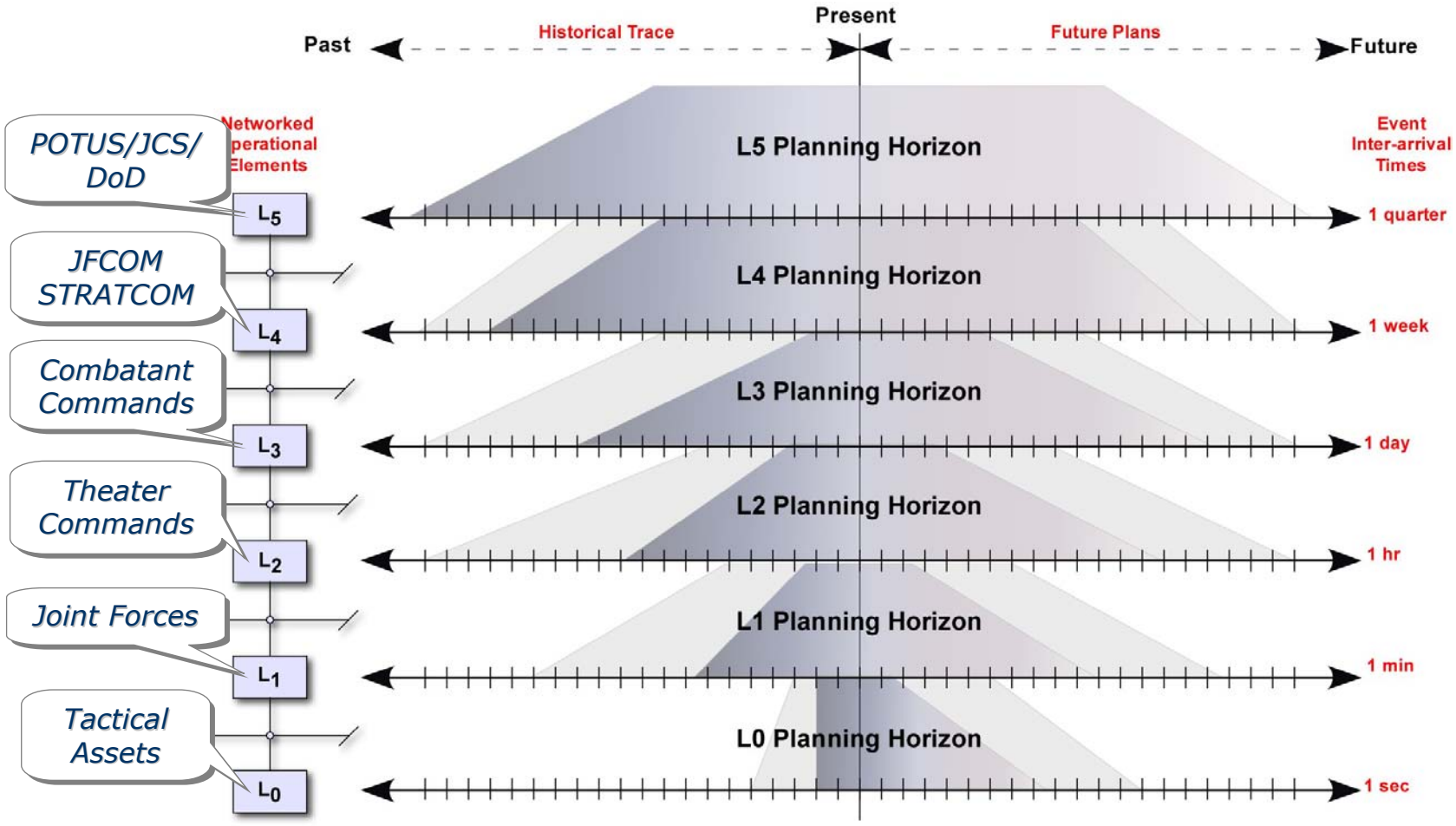
⇒ Collaborative C2 services should include support for specific elements of *situation assessment*, *plan generation* and *plan execution*

C2 Policy Domains

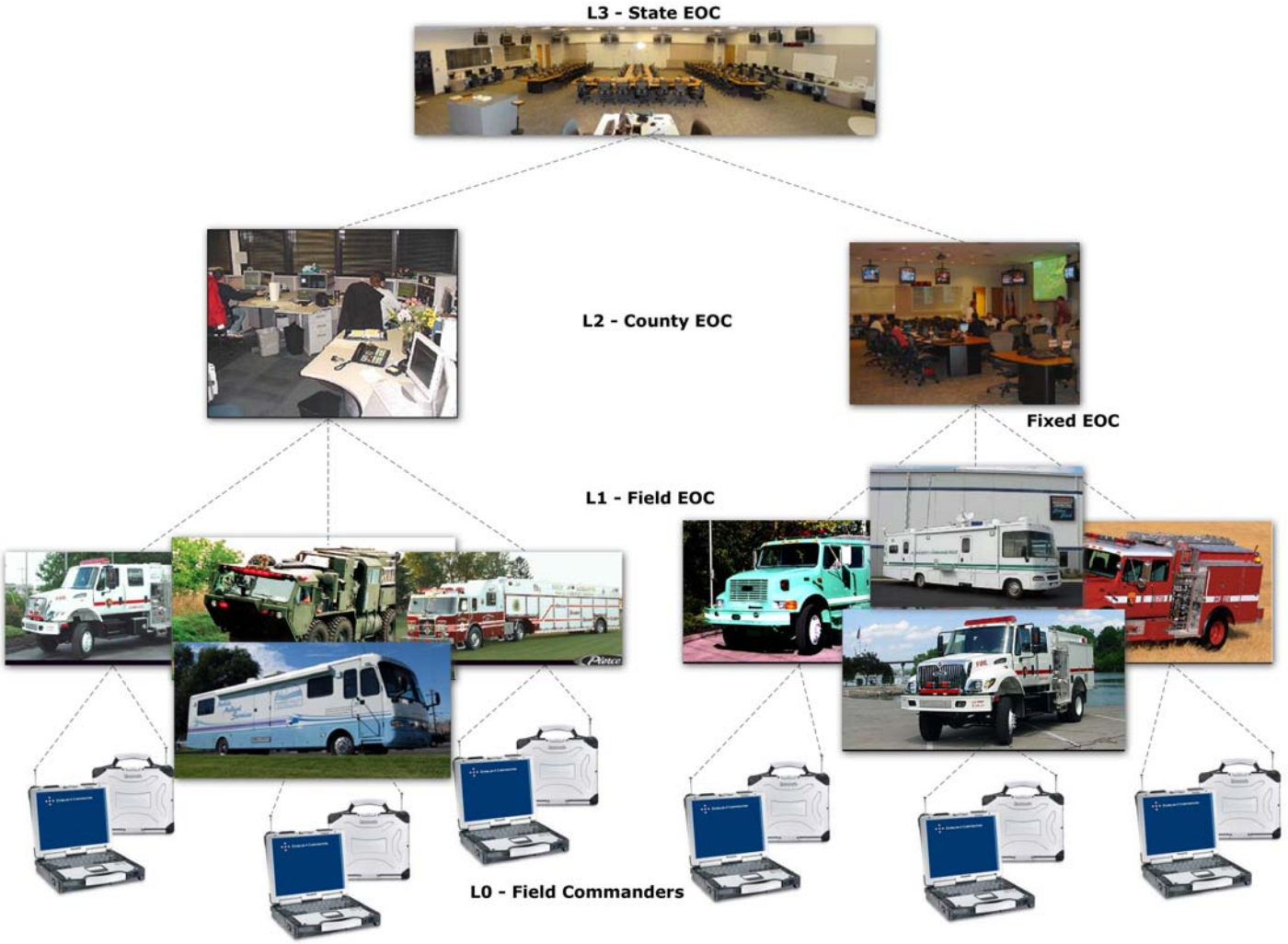


- An enterprise *accountable* to the degree it operates in a traceable command or policy domain hierarchy
- A C2 system is *scale-free* to the degree that policies and processes scale uniformly from the lowest tactical levels to the highest strategic levels of command
- A scale-free system is *manageable* to the degree it supports a uniform *performance measurement framework* that is policy domain neutral

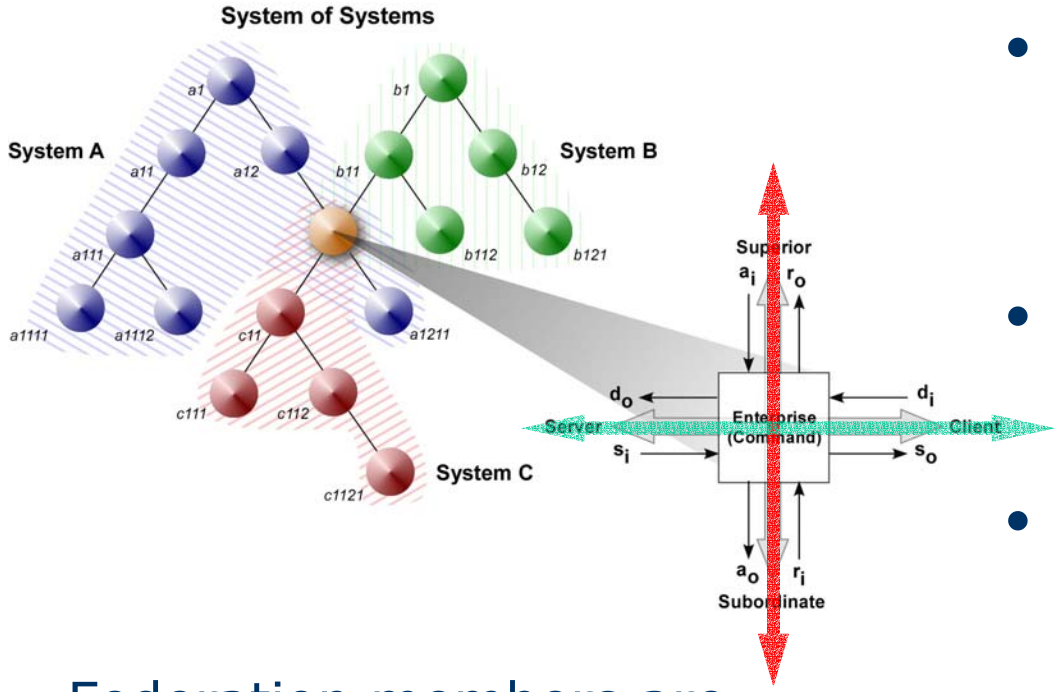
Scale: *C2 Space*



Civilian DHS-ICS Example



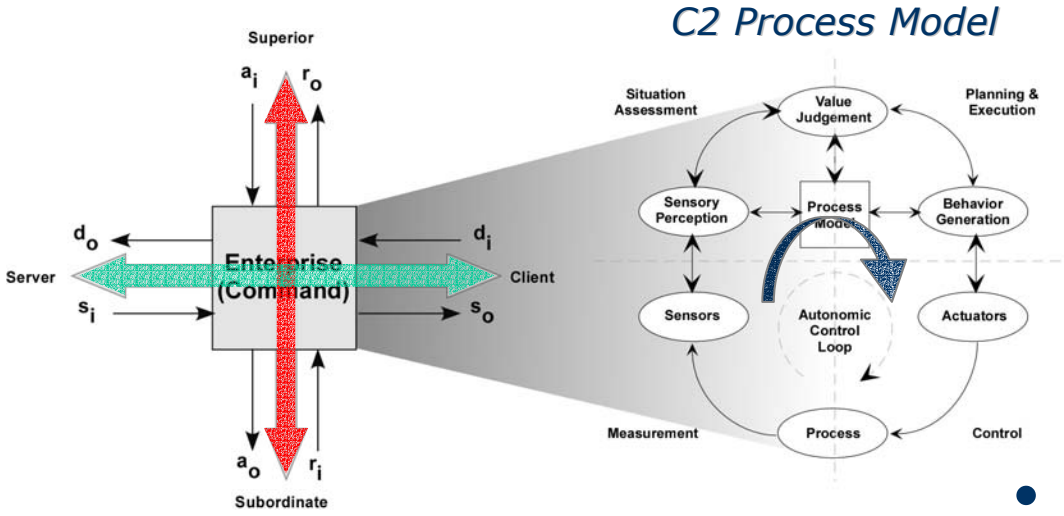
Systems of Federated C2 Systems



- Federation members are
  - Uniquely Identifiable
  - Self Directed (Semi-Autonomous)
  - Freely Associative, and
  - Mutually Interdependent

- A given enterprise may participate in multiple federations (systems of systems)
- Each federated entity is considered a *command*, or *value production unit*
- A command is a four port object operating in a lattice or mesh interconnected by a
  - Command Axis (superior-subordinate)
  - Service Axis (client-server)

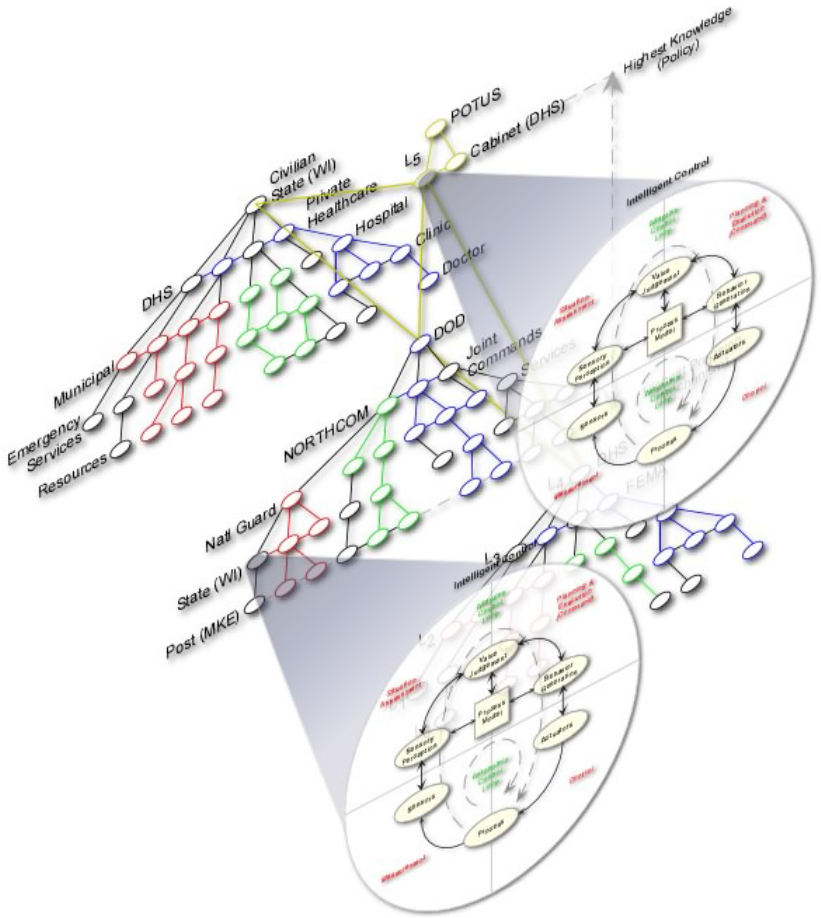
C2 Process Model



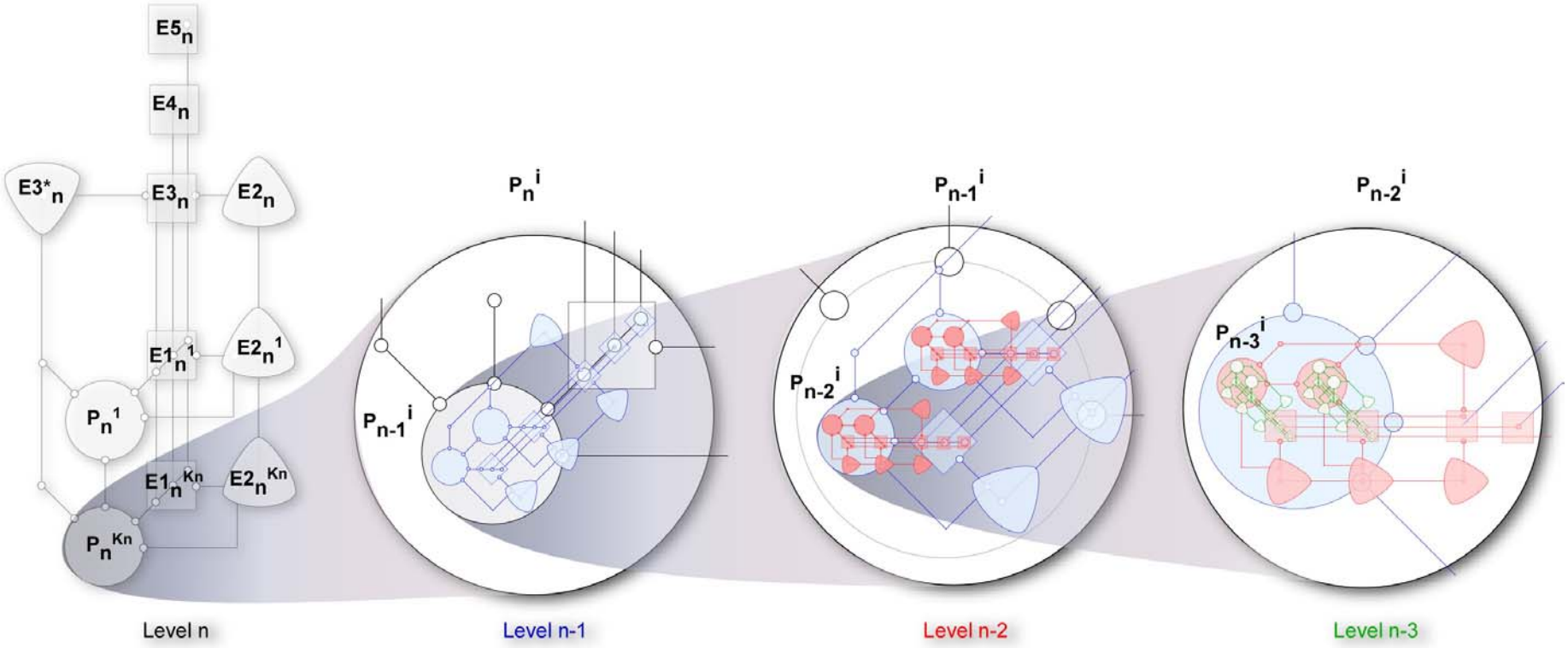
- Federated enterprise management has two simultaneous objectives:
  - Maintaining command chain commitments (viability, homeostasis)
  - Maintaining supply chain commitments (service level agreements)
- Automation of core processes (autonomic controls) is a proven means of improving performance (yield, quality, etc.)

Scale-Free C2 Actor Model

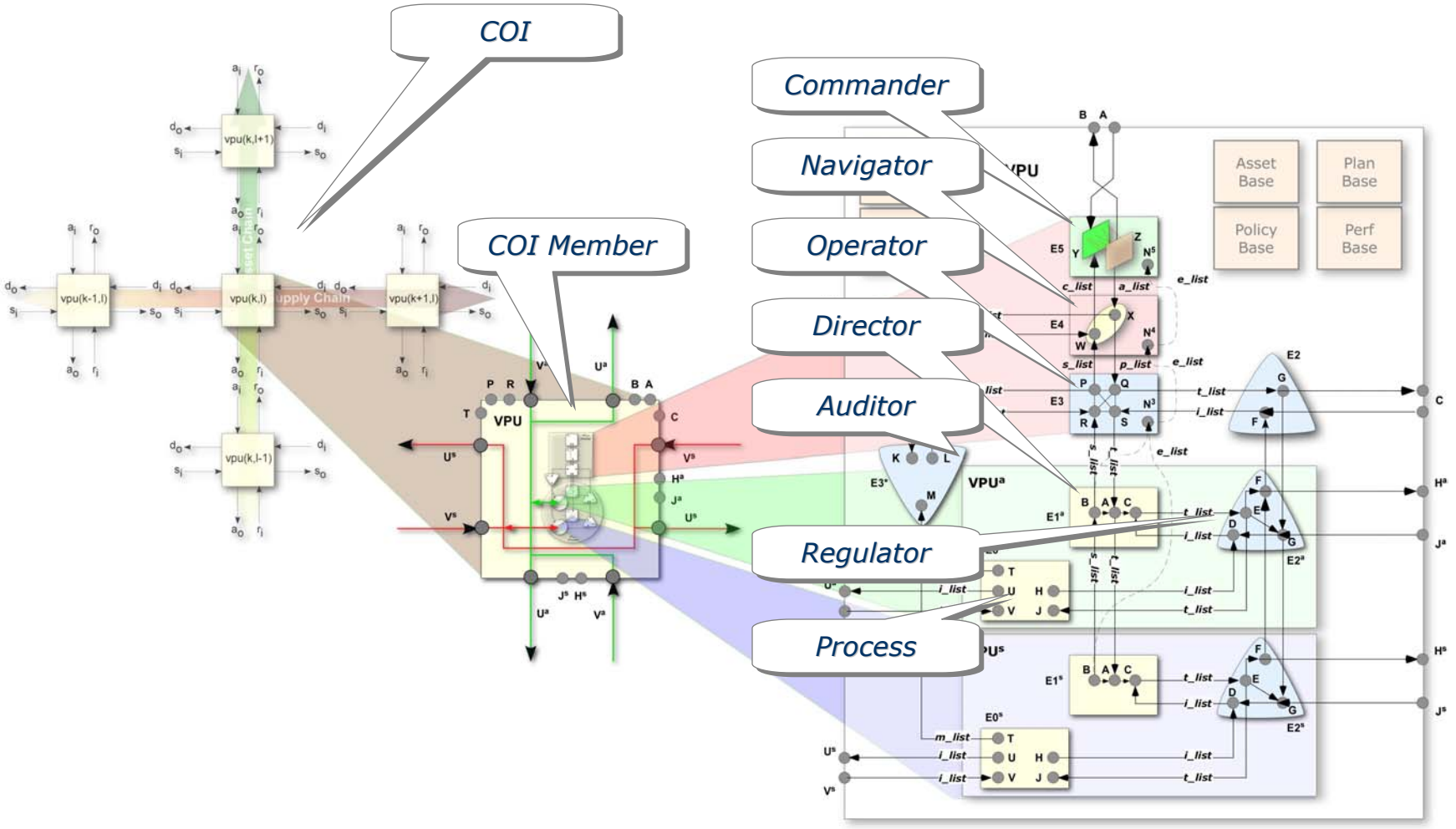
Always-On Distributed C2



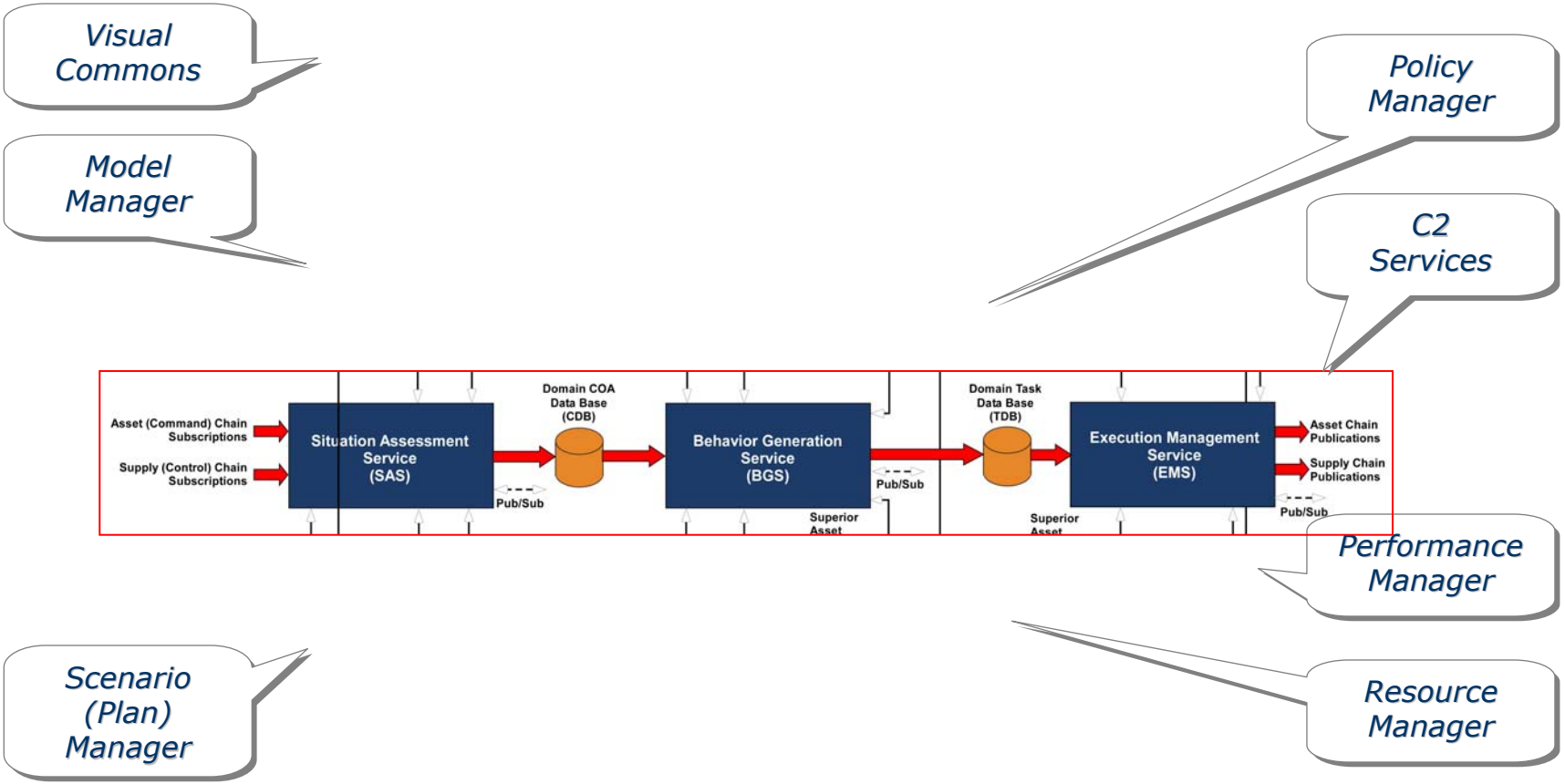
Recursive (Fractal) C2



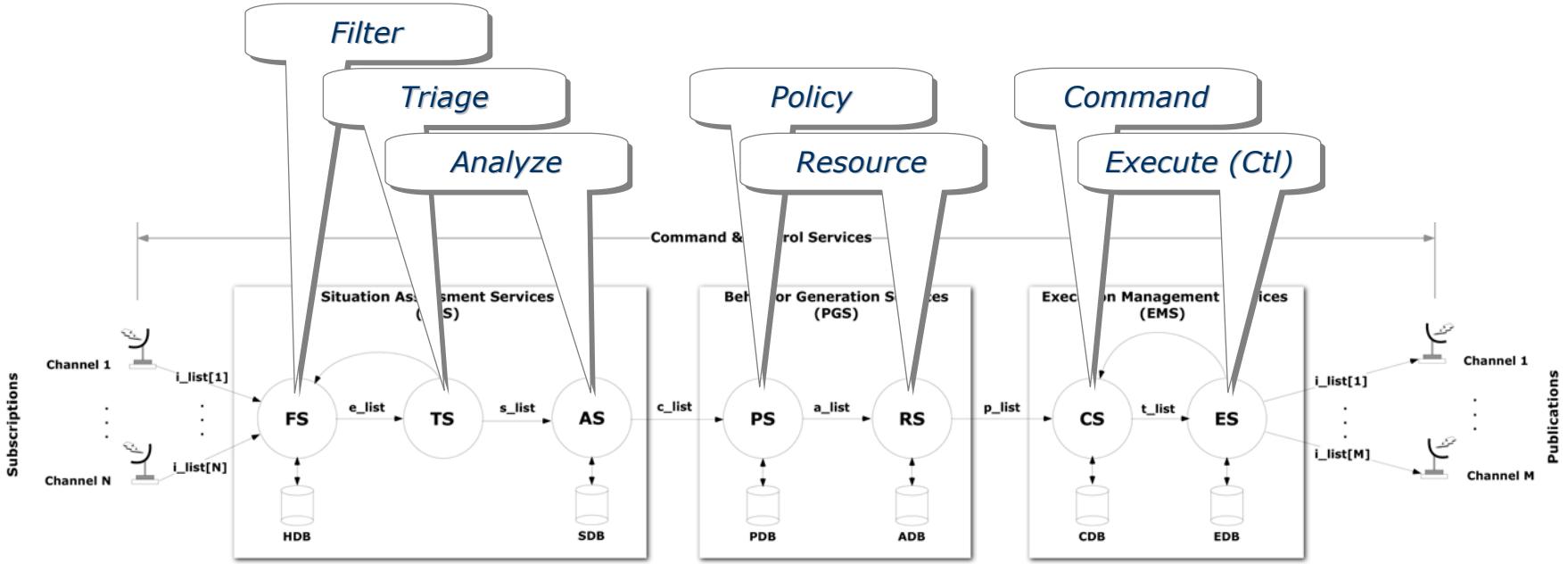
Federation C2 Actor Model



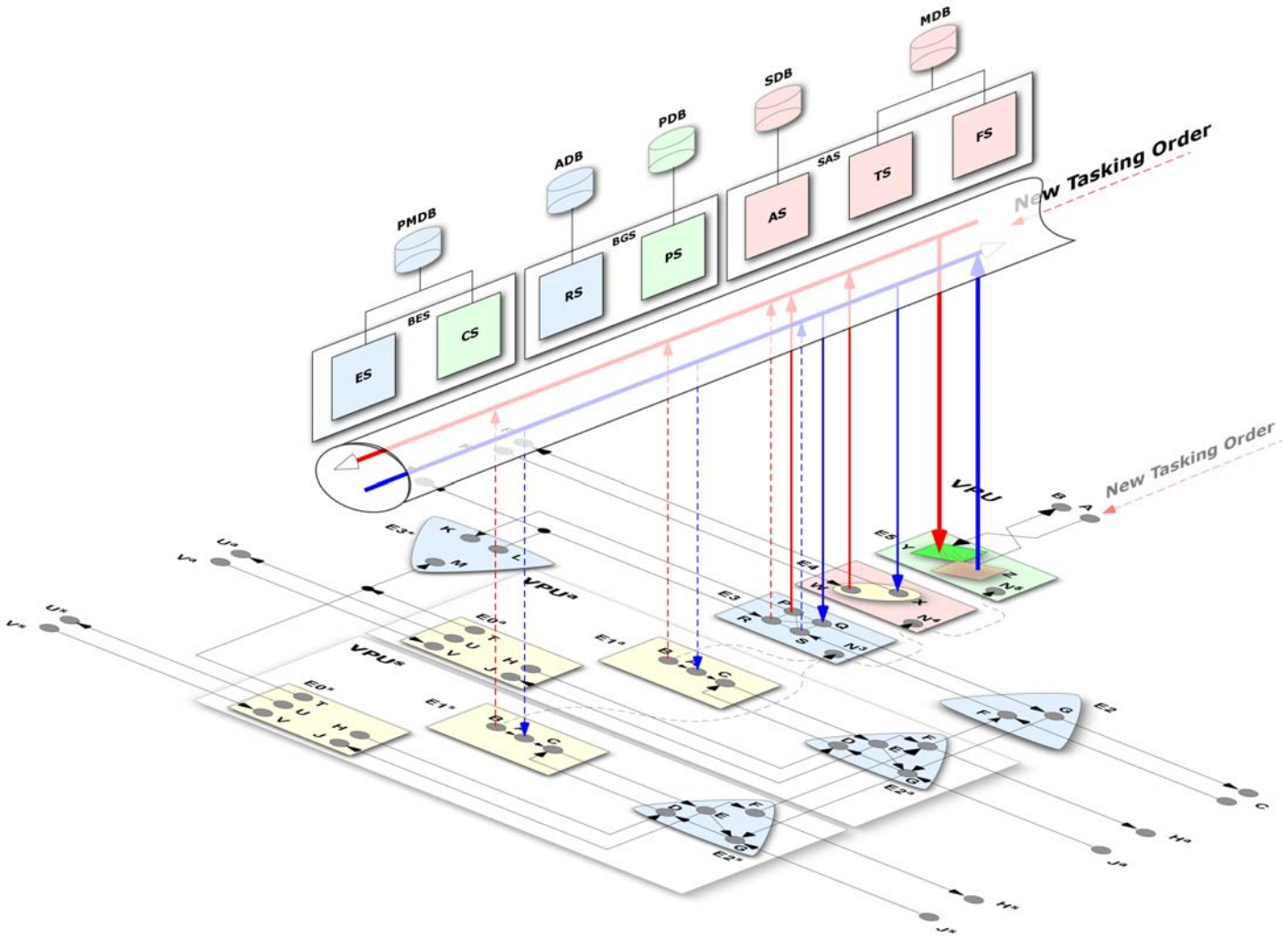
C2 System Overview



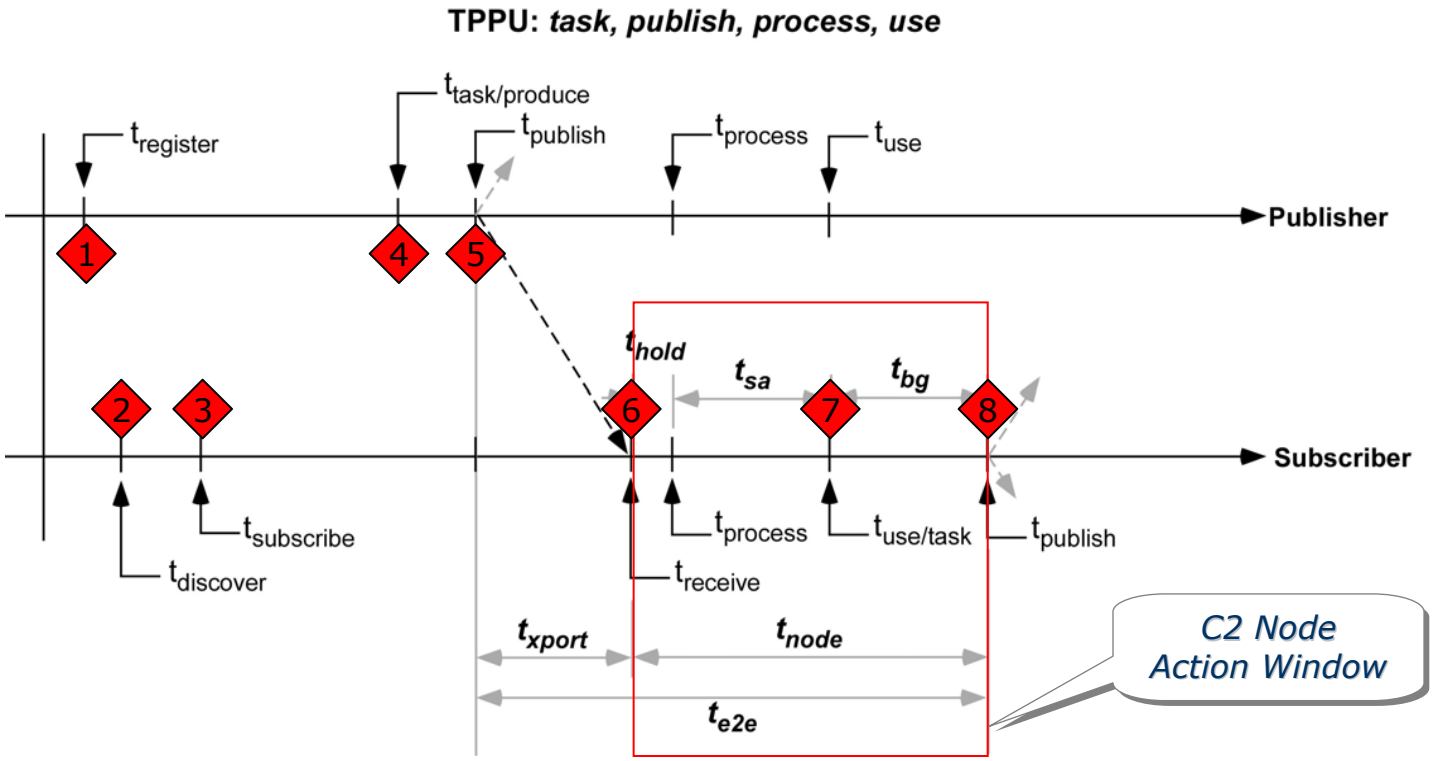
C2 Application Services



C2 Node Structure

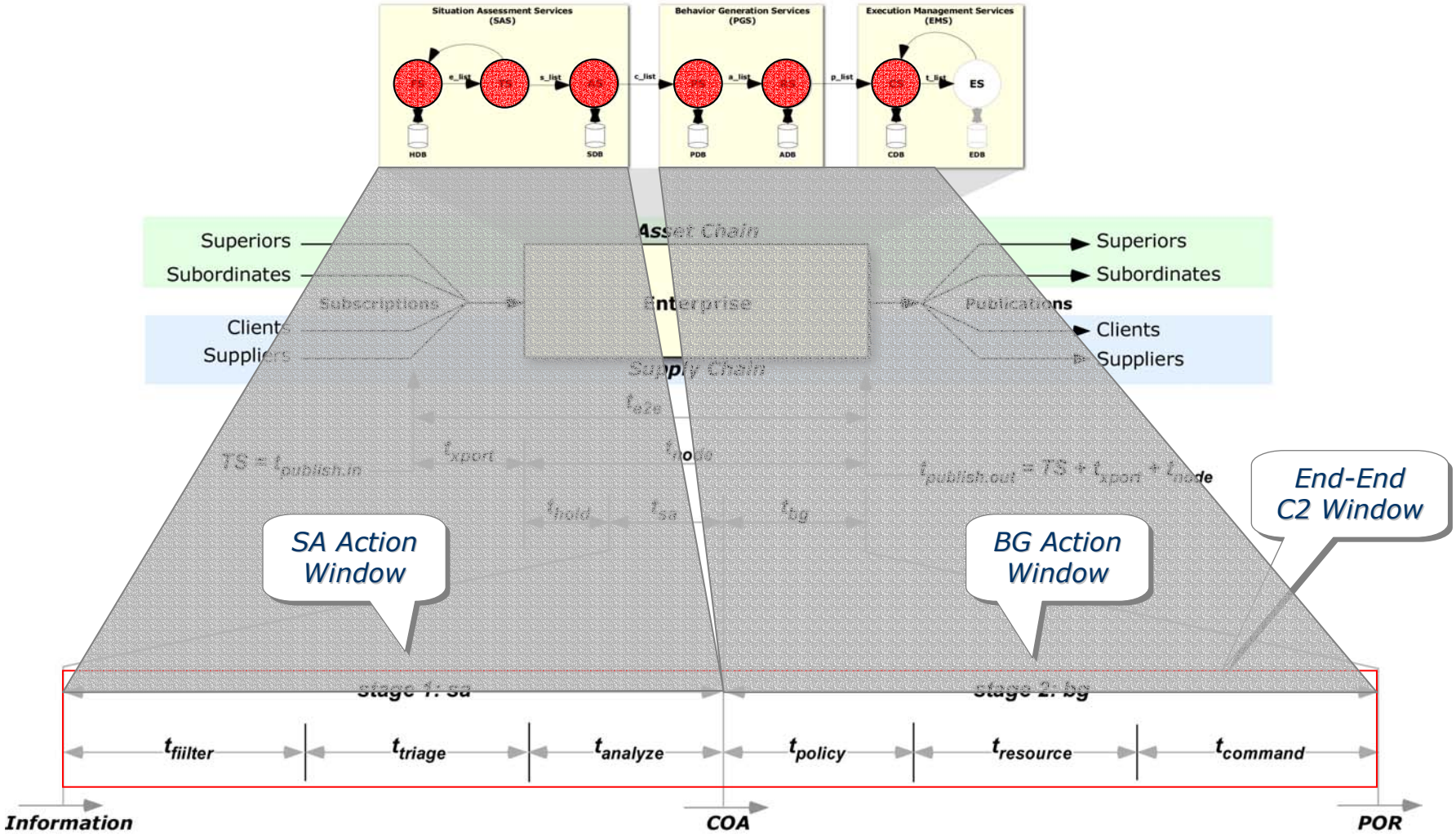


TPPU Timing Requirements

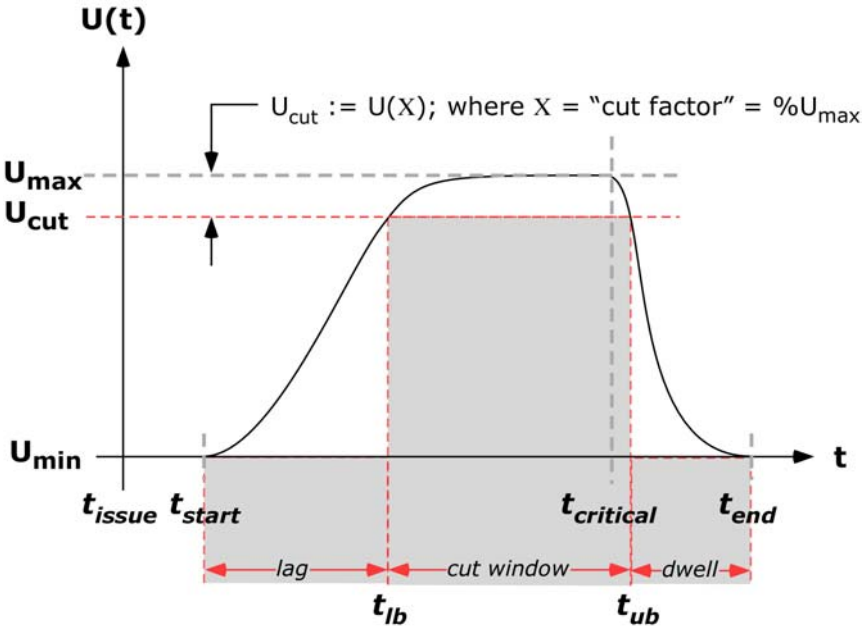


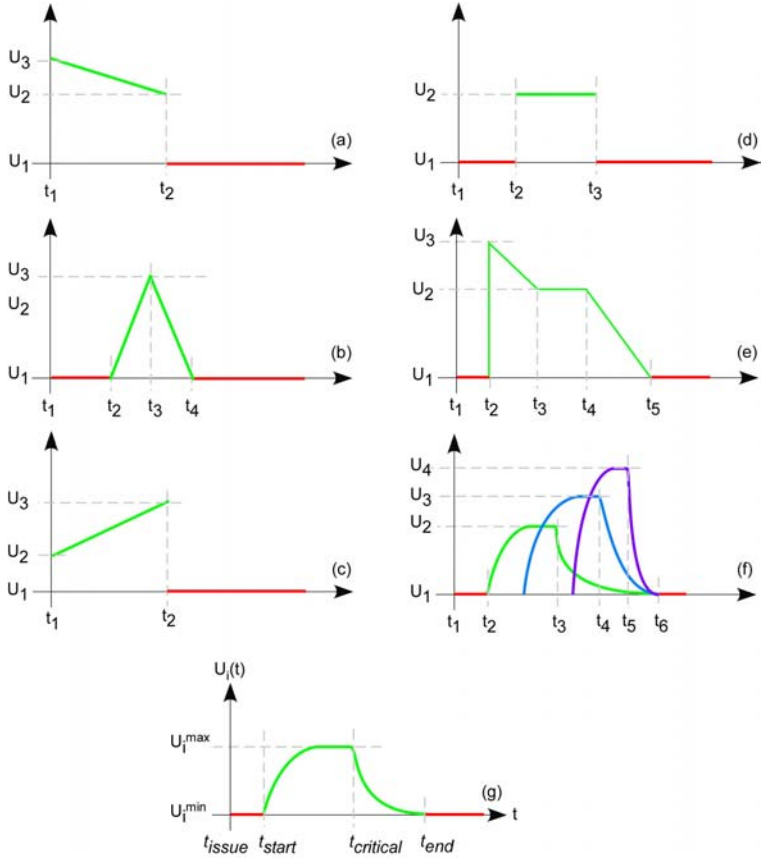
- Real-time => Meeting completion time requirements
- Grid-based => IP connected with publish-subscribe services

C2 Node Timing

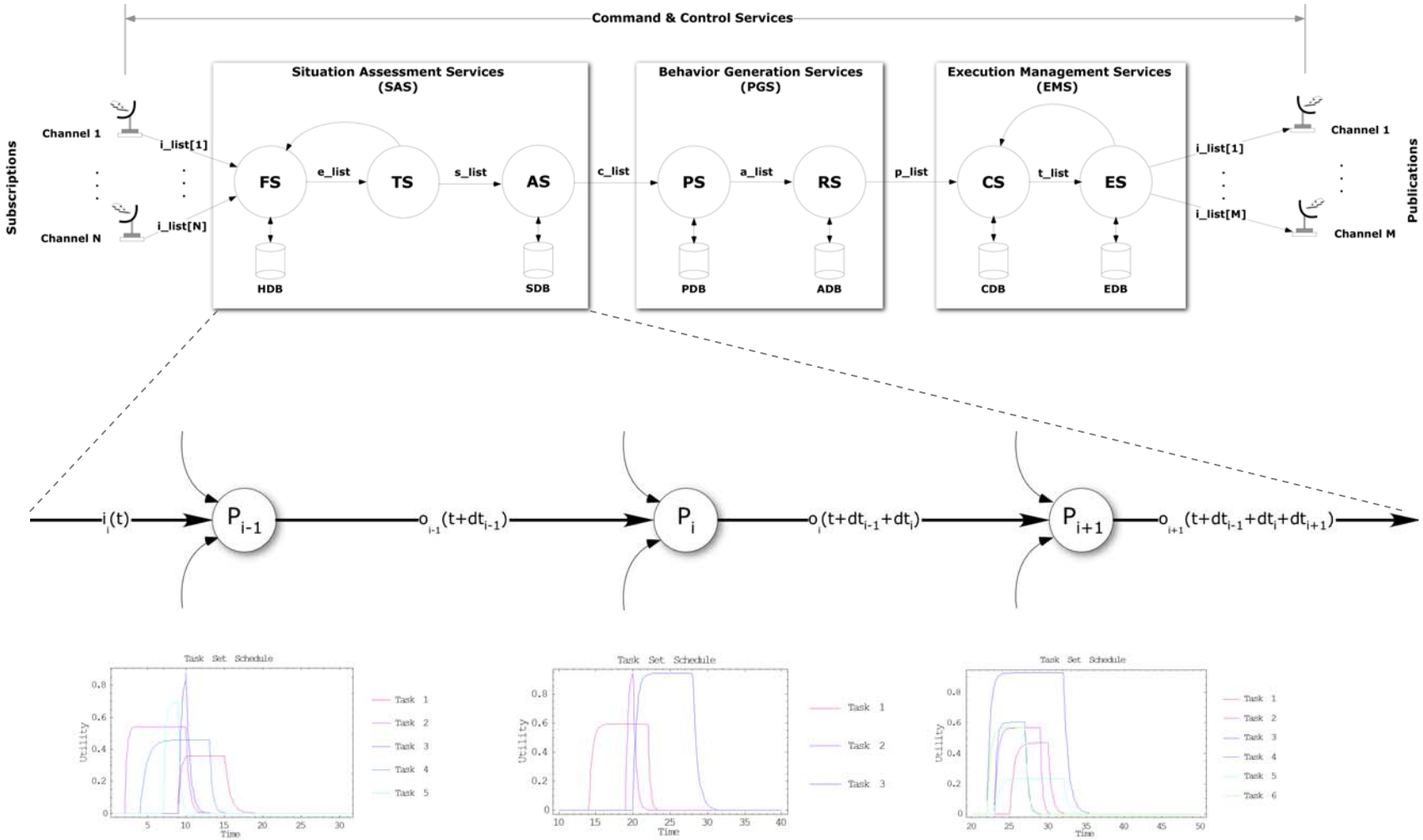


Completion-Time Requirements

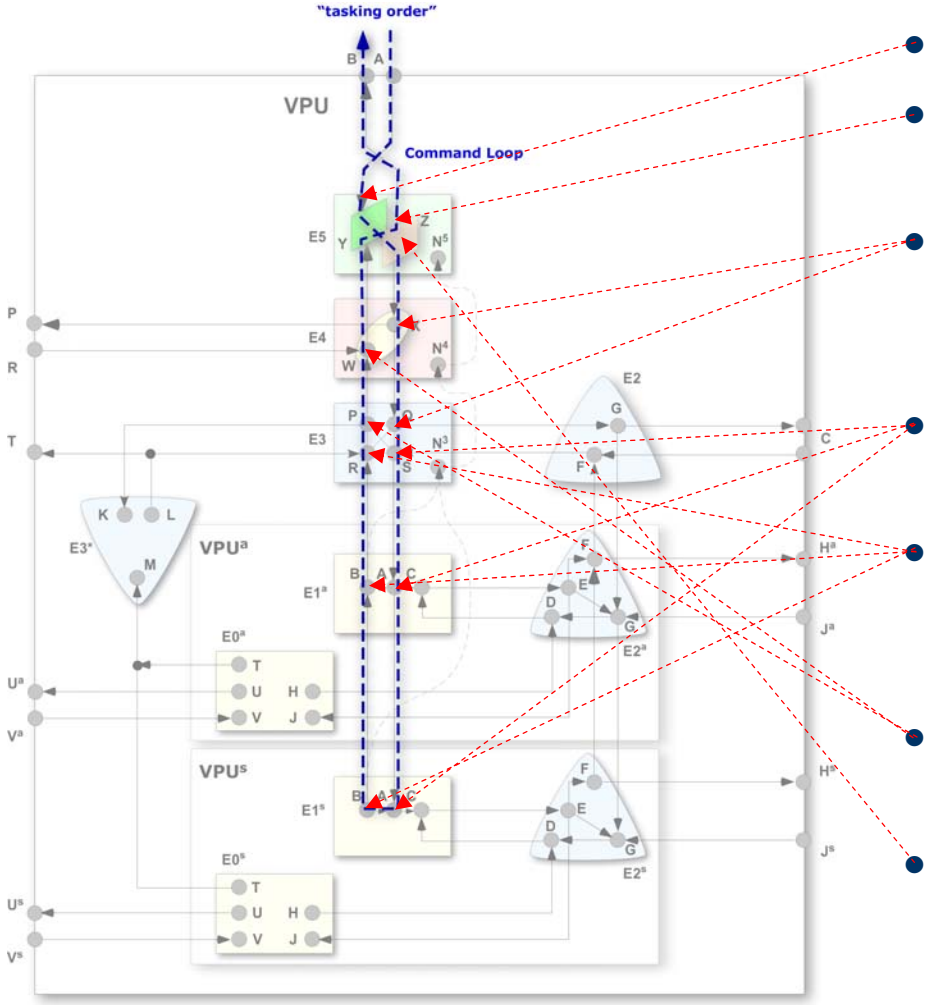




C2 Time Management

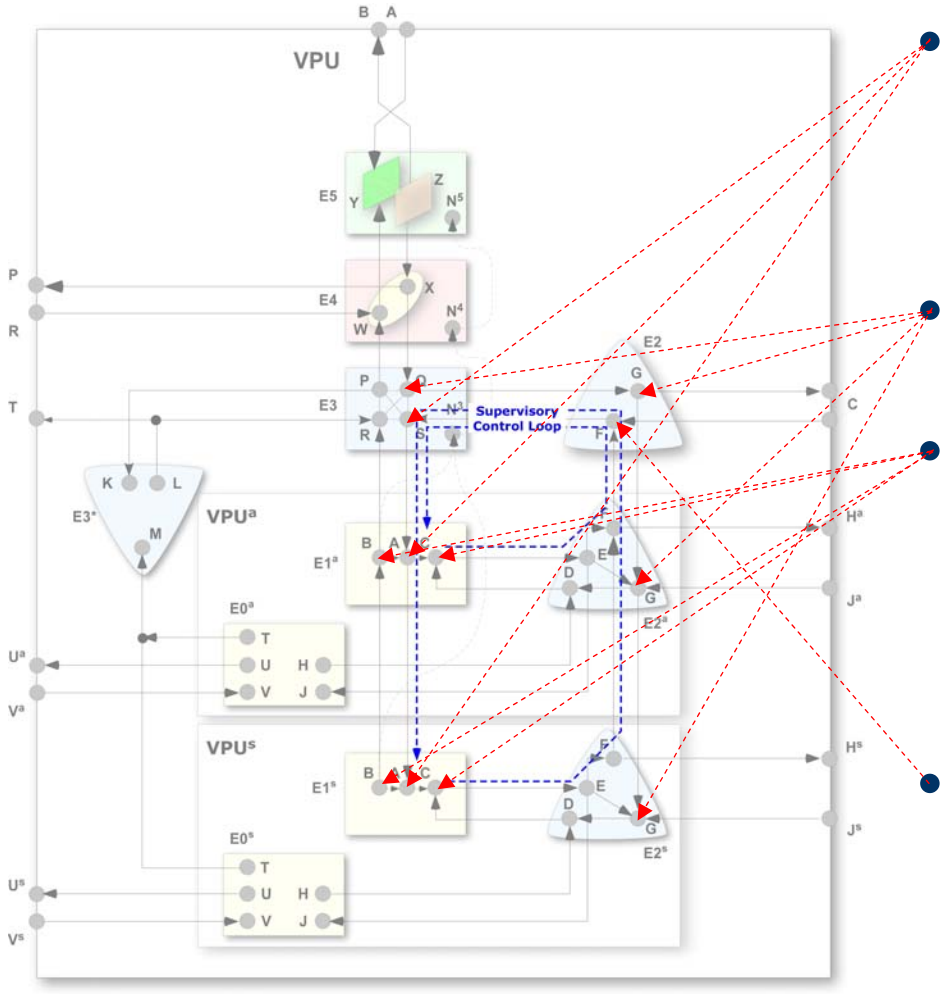


Tasking Order Propagation



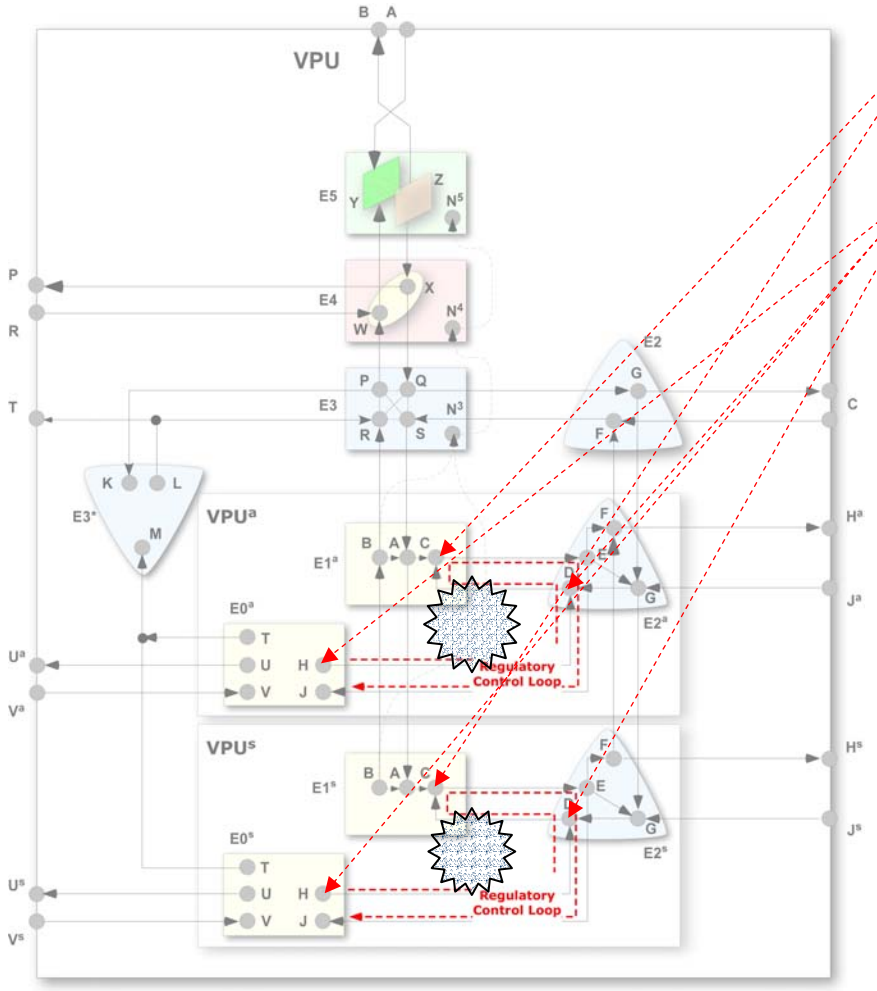
- Commander (E5) receives TO
- Commander (E5) acknowledges receipt
- Commander requests review by staff, Analyst-Planner (E4) and XO (E3)
- XO (E3) requests E1 Director review and response capability
- Directors respond with capabilities (resources, timing, etc.)
- Planner and XO produce response plan
- Commander authorizes action

Task Execution Scheduling



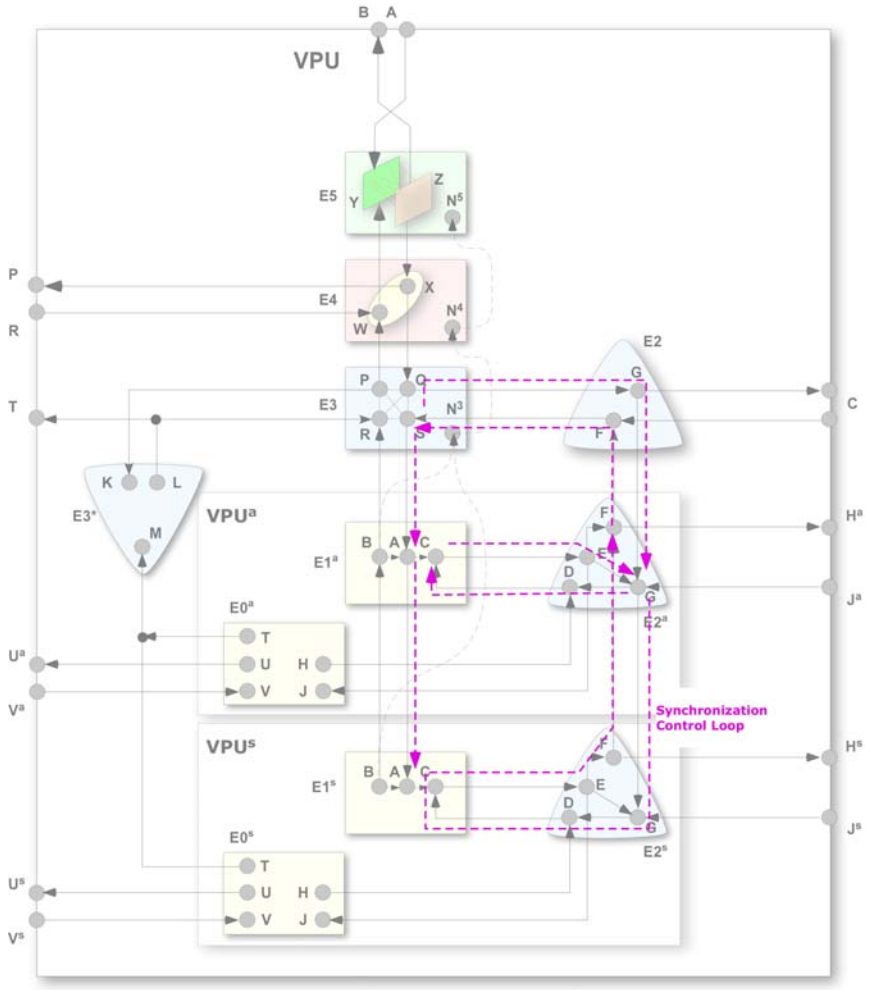
- E3 Operator issues tasking orders (TO) to subordinates (E1a and E1b Directors)
- E3 establishes synchronization logic
- E1a and E1b Directors "program" their Regulators (E2a and E2b) and acknowledge acceptance of TO to E3
- Regulators acknowledge synchronization requirements to E2

Autonomic Task Execution



- E1a and E1b initiate action on TO
- Their respective Regulators monitor execution in the E0a and E0b "production processes"

Task Synchronization



- For task rendezvous and resource sharing, E1a and E1b Regulators monitor and synchronize (e.g., mutex) for E3 Operator

Thank You!

Are there any questions?