To Cross-Layer or Not: Cross-Layering vs. Strict Layering vs. No Layering

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Panel Discussion - To Cross-Layer or Not: Cross-Layering vs. Strict Layering vs. No Layering

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Strict Layering

**Taxonomy:**
+ organization of complex communication system
  – exceptions are the rule

**Abstraction:**
+ isolation of network control functions
  – interactions obscured

**Hierarchy:**
+ few interfaces between functions
  – complicated interfaces
  – processing delays for information exchange
Cross-Layering

Cognizance of behavior of other layers:
+ fosters synergism between control functions
+ reduces redundant functionality
– requires system-wide knowledge

Exchange of information between arbitrary layers:
+ well-informed control decisions
– potentially many interfaces
– stability and robustness of control

Integrated design of multiple layers:
+ tailoring for specific contexts
+ optimization
– loss of generality
– complicated implementation
No Layering

Set of control algorithms:
goals, inputs, and actions
open or closed loop
responsiveness
temporal duration and spatial extent of response
interactions

Retain:
+ modularity
+ well-defined interfaces

Gain:
+ function-oriented view of communications system
+ flexibility of design
+ efficiency and simplicity of implementation
Mobile Ad Hoc and Sensor Networks

Stimuli for cross-layering:
- quality of service (sensor and ad hoc networks)
- security (sensor and ad hoc networks)
- energy (*consumption* primarily for sensor networks, *dispersion* primarily for ad hoc networks)

Challenges:
- channel (sensor and ad hoc networks)
- batteries (sensor networks)
- electronics (sensor networks)
Sensor Networks

Communication and computation trades for controlling energy consumption:
- set of recipients
- schedule for transmissions and sleep/wake cycles
- compression of transmitted information
- fusion of received information

Most effective use of cross-layering for networks of simple sensors is likely to be in network design:
- off-line optimization is reasonable if node trajectories, traffic demands, and environmental conditions are well-known
- but must still be able to deal with unforeseen dynamics
Ad Hoc Networks

Communication, computation, and mobility trades for controlling energy dispersion:
- set of recipients
- schedule of transmissions
- compression of transmitted information
- trajectories of nodes
- frequency
- transmit power
- modulation
- error control coding and retransmissions
- beam width and direction

Most effective use of cross-layering for networks of mobile nodes is likely to be in packet-by-packet adaptation:
- transceivers, antennas, and mobile platforms offer additional dimensions for control
- accurate knowledge of channel is critical
Middleware

Can the use of middleware (as an alternative to cross-layering) help conventional layering adapt to the tactical wireless environment?

Translation:
- convert syntax and semantics of information passed from source layer into form needed by target layer

Information collection and distribution:
- gather information from layers as needed by other layers
- make information available to layers as needed for control

Adaptation:
- add desired control functions to adjacent layers without modifying those layers