A Recursive Network Architecture

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Motivation

- Layers of a stack becoming more similar
  - Security, soft-state, pacing, retransmission
- Desire to support interlayer cooperation
  - Message boundary, cong. control, compression vs. encryption interactions
- Desire to support overlay layers
  - Clearly needed, but don't map to 1-7

Is layering more than a coding artifact?

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Internet Architecture

Accused of ossification, but:

- Ossification = stability
- Flexibility is abundant:
  - Shim layers:
    - HIP, SHIM6, IPsec, TLS
  - Muxing layers:
    - SCTP, RDDP, BEEP
  - Connections:
    - MPLS, GRE, IKE, BEEP, SCTP
  - Virtualization:
    - L2VPN, L3VPN/X-Bone/RON/Detour, L7-DHTs

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Challenges of Layering

- Which to add...
  - IPv4/IPv6, TCP/DCCP/SCTP
- When to add...
  - Security, muxing, cong. control
- Real vs. virtual
  - What's the difference?

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Observations

1. Services are relative
2. A template can avoid recapitulation
3. Composition requires coordination

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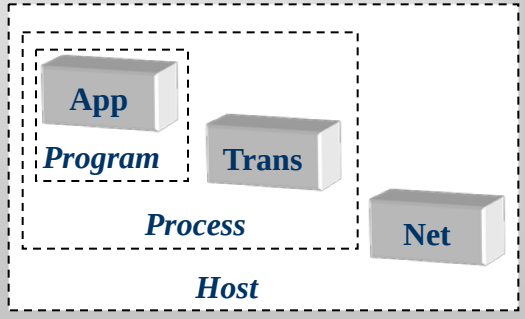
The OSI 7-layer Model

- Layer indicates function
- But...
  - Functions are recapitulated:
  - Formatting at link and presentation
  - Muxing at transport and session

Scope defines a layer

- Its endpoints
  - A “hop” @layer N = E2E extent of layer N-1
- The layer above
  - What services this layer provides
- The layer below
  - What services this layer requires
- E.g.: Shared state at diff. layers for diff. services
  - Application binding
  - Transport delivery
  - Net security



The difference is scope

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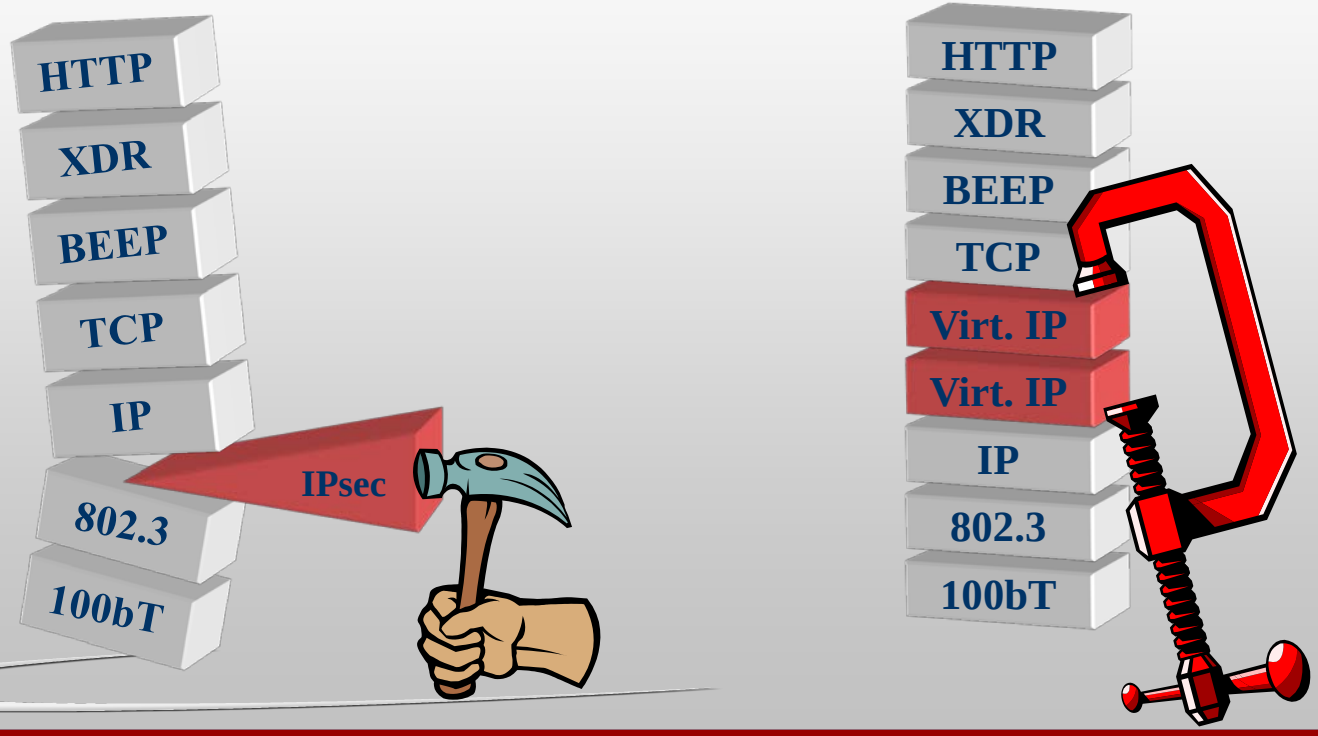
Adding Services is Hard

- Wedge between (IPsec, left)
  or replicate (virtualization, right)



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Recapitulation

- Component services repeat:
  - handshake / state management
  - security
  - policy (admission control, filtering)
  - multiplexing and demultiplexing
  - retransmission
  - reordering
  - pacing / congestion control
  - switching / forwarding
- Compounded by virtualization
  - Layer on layer on layer

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Composition Requires Coordination

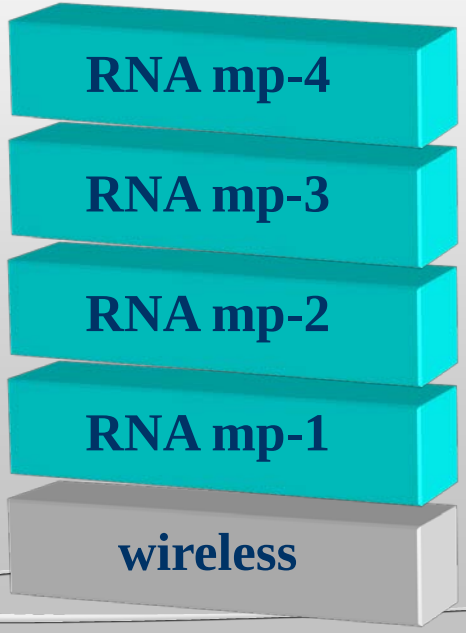
- Many services integrate layers
  - Congestion control
  - Message boundaries
  - Security
  - State establishment
- Current interlayer interface is limited
  - Defined by each layer
  - No general security, state, etc. interface

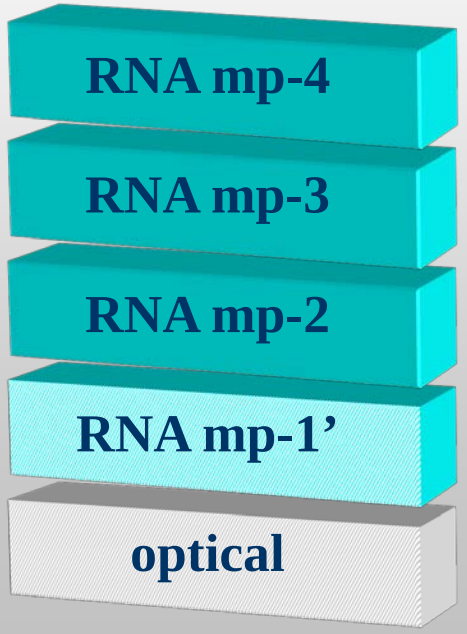
RNA Stack

- Only needed layers
  - With only needed services
- One MP, many instances
  - Configurable like TP++
  - Retain layers to limit scope
  - Context-sensitive

Layer Context Sensitivity

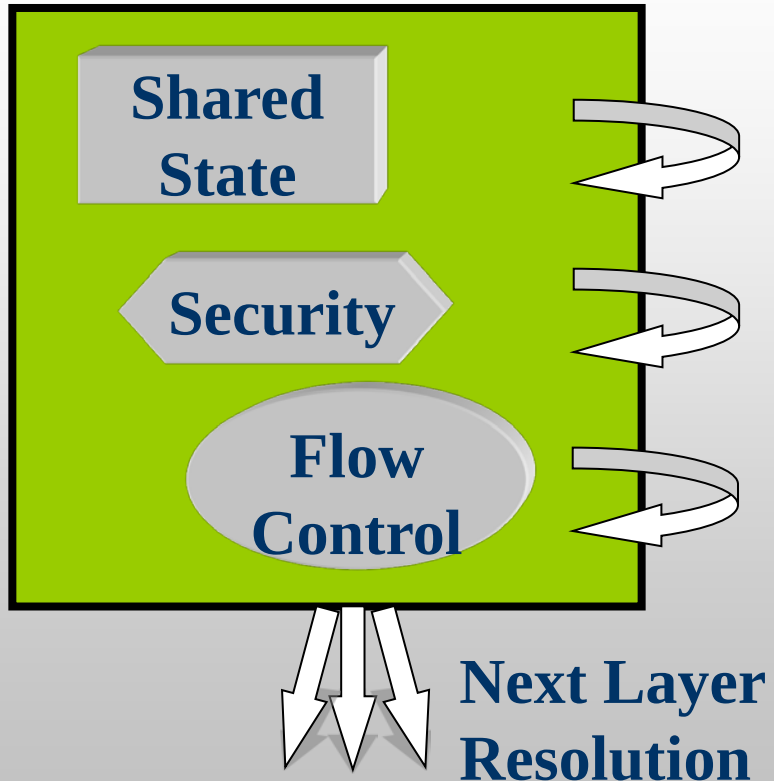
- E.g., mp-1 morphs varies when over wireless vs. optical
  - Opportunity for auto-tuning





RNA Metaprotocol

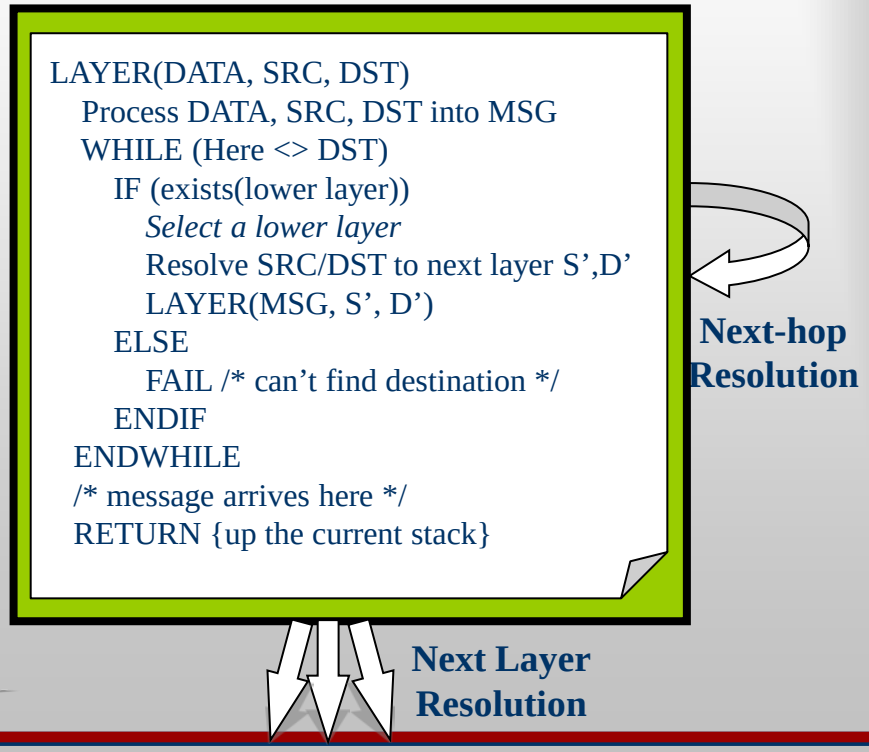
- Template of basic protocol service:



MDCM from *Choices*

Dynamic interlayer glue

- One template for ARP, BGP, IP, DNS
  - Also for 'BARP'
- Structured template
  - With plug-in funcs.



Components of RNA MP

Instantiate MDCM's "Process DATA"

- Establish / refresh state
- Encrypt / decrypt message
- Apply filtering
- Pace output via flow control
- Pace input to allow reordering
- Multiplex/demultiplex as indicated
  - includes switching/forwarding

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Challenges

- MP design
  - Building a sensible, generic template
- Stack management
  - Supporting instantiation and composition
- Supporting interlayer coordination
  - Designing a sensible, recursive API
  - Makes it easier to interface (to yourself, *e.g.*, LEGO)
- Supporting context sensitivity
  - Detecting environment and autotuning

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Related Work

- Modular protocol environments
  - Click, x-Kernel, Netgraph, Flexible Protocol Stacks
  - *RNA adds a constrained template*
- Template protocol models
  - MDCM, RBA
  - *RNA adds structured sequence of services*
- Context-sensitive protocols
  - PEPs, Shims, intermediate overlay layers, etc.
  - *RNA incorporates this into the stack directly*
- Configurable protocols
  - XTP, TP++, SCTP
  - *RNA makes every layer configurable, but keeps multiple layers.*

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Status

- Ongoing stack/protocol survey
  - Scope vs. layer structure
  - Intra-/Interlayer ‘feature creep’
  - Intra-/Interlayer bindings
- Observation: Inclusive Scoping Issues
  1. Layers have static, linear lineage
     - Works well for messages/streams; poorly for connections
  2. Services are satisfied top-down
     - Consequence of ‘E2E argument’ + #1

www.isi.edu/rna