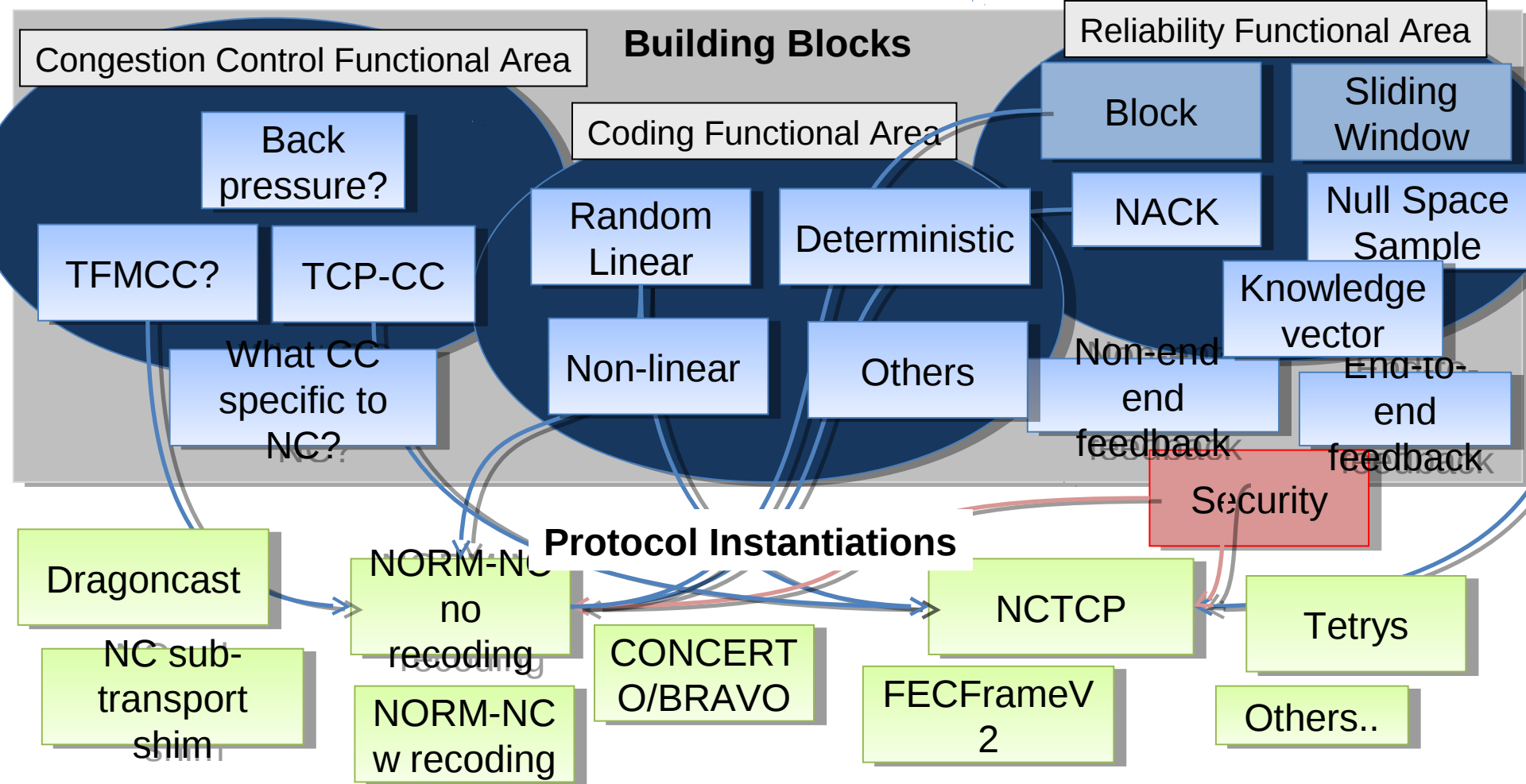

Network Coding Architecture Framework

Victor Firoiu, Brian Adamson
with inputs from Vincent Roca, Morten Pedersen

IETF 93

2015-07-20

Network Coding Building Blocks



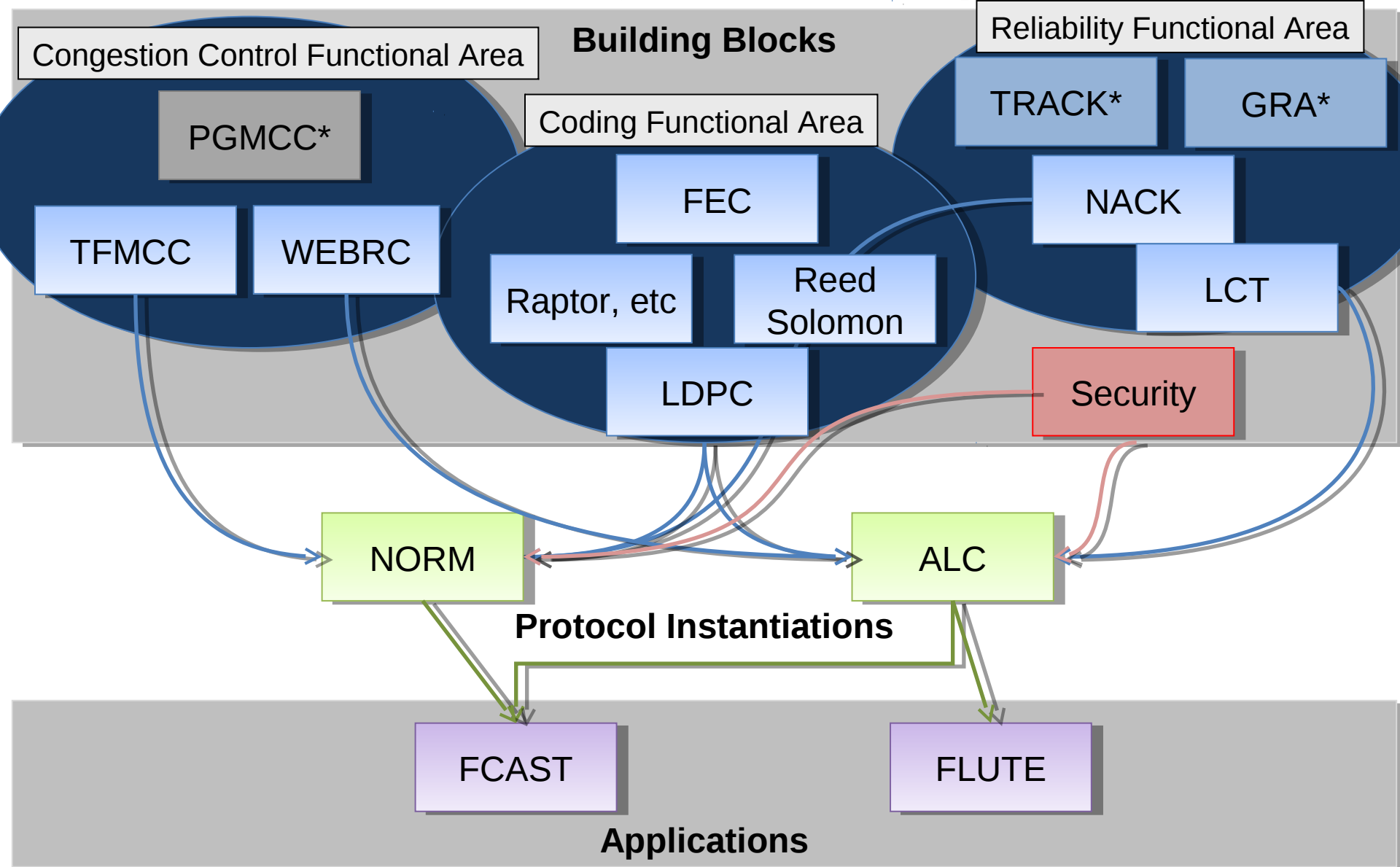
NC Architecture/ Framework Document

Goals:

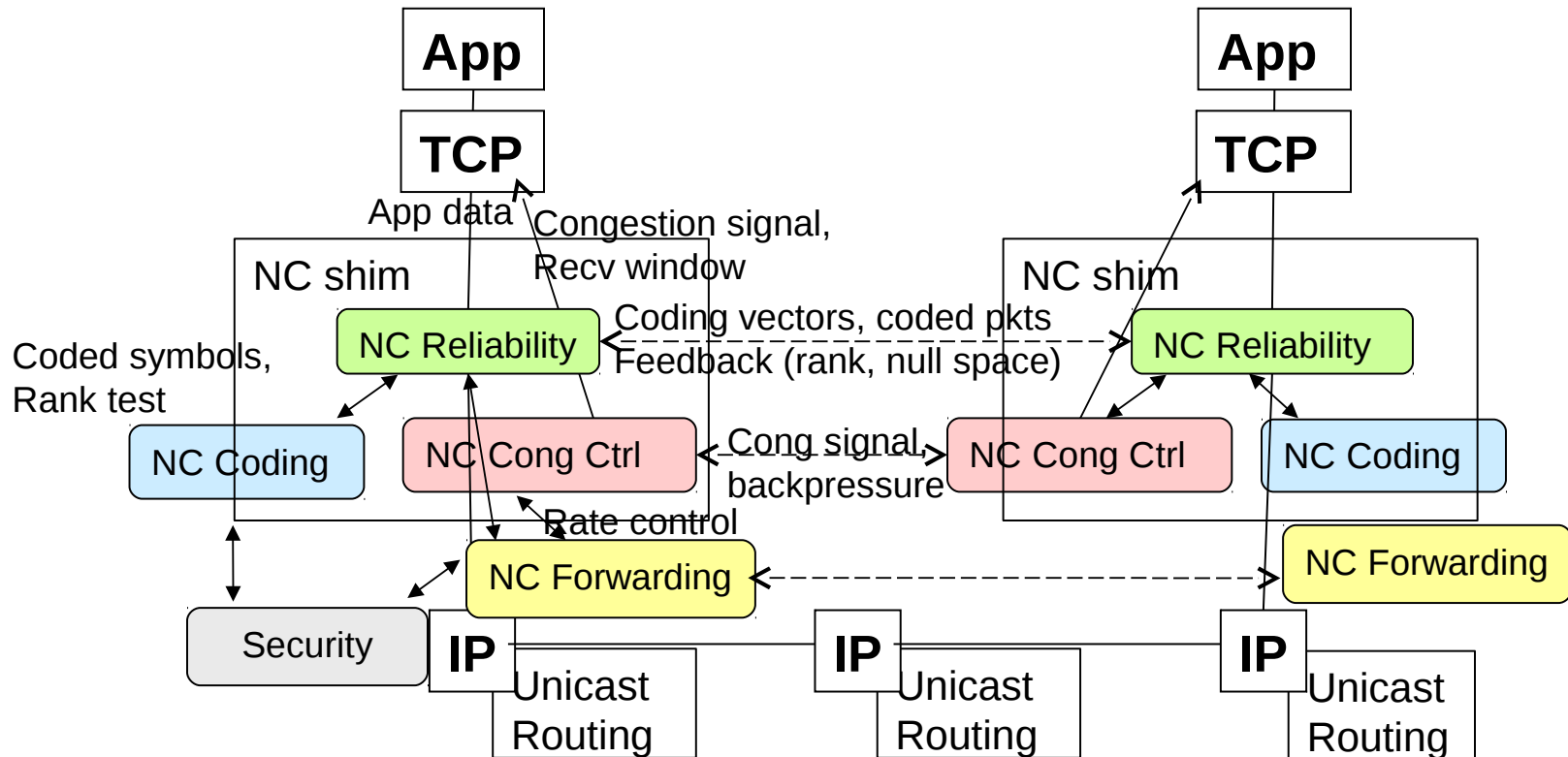
- Identify building blocks to be defined in separate documents
 - And uncover open research questions
- Identify interactions between BBs, new functionalities to research
 - E.g.: what Congestion control function is needed specific to NC?
- Outline a path toward a small set of protocol instantiations – for future standardization

Backup Material

RMT Building Block Approach

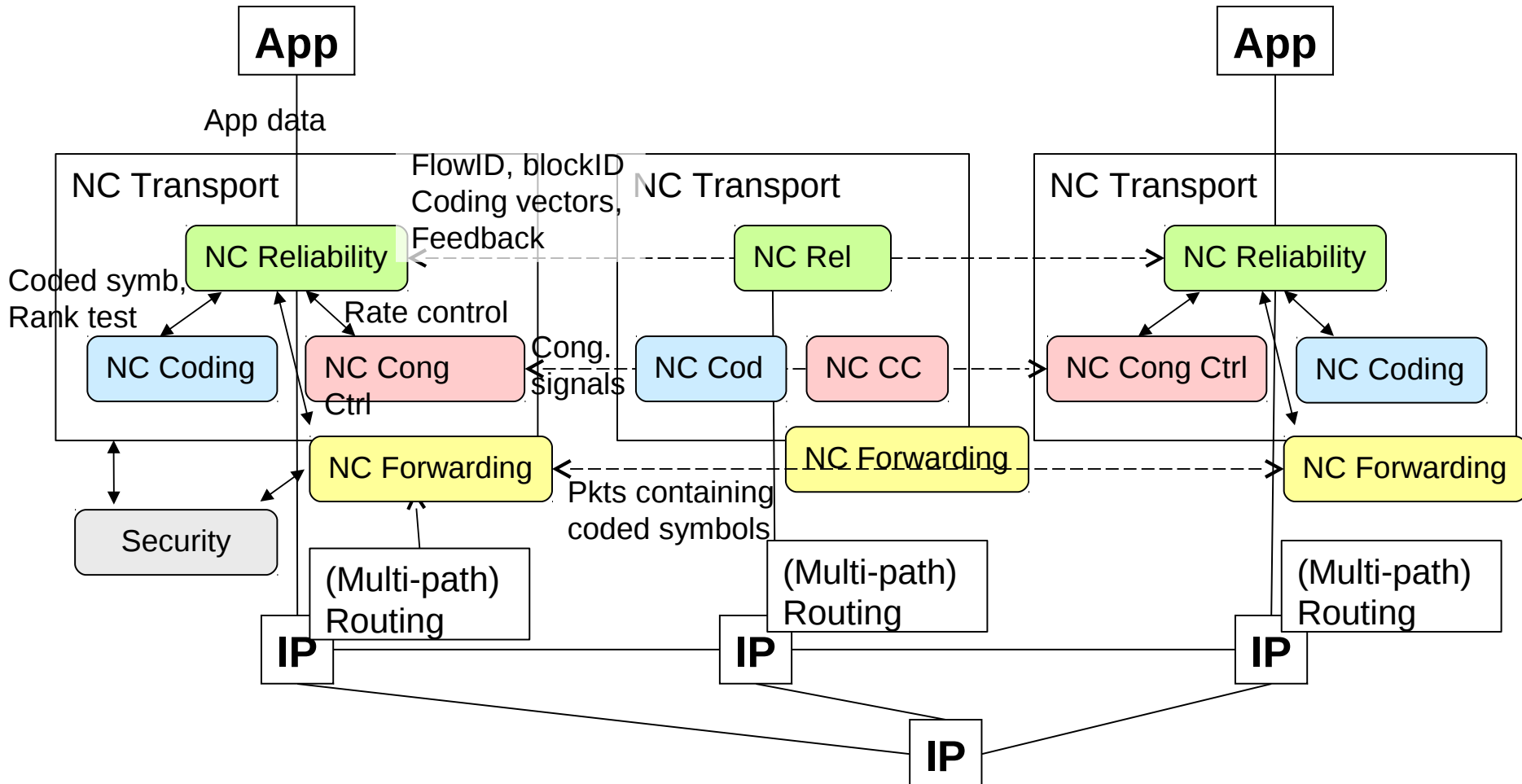


Use Case 1: NC Shim Layer – under TCP, UDP, SSH



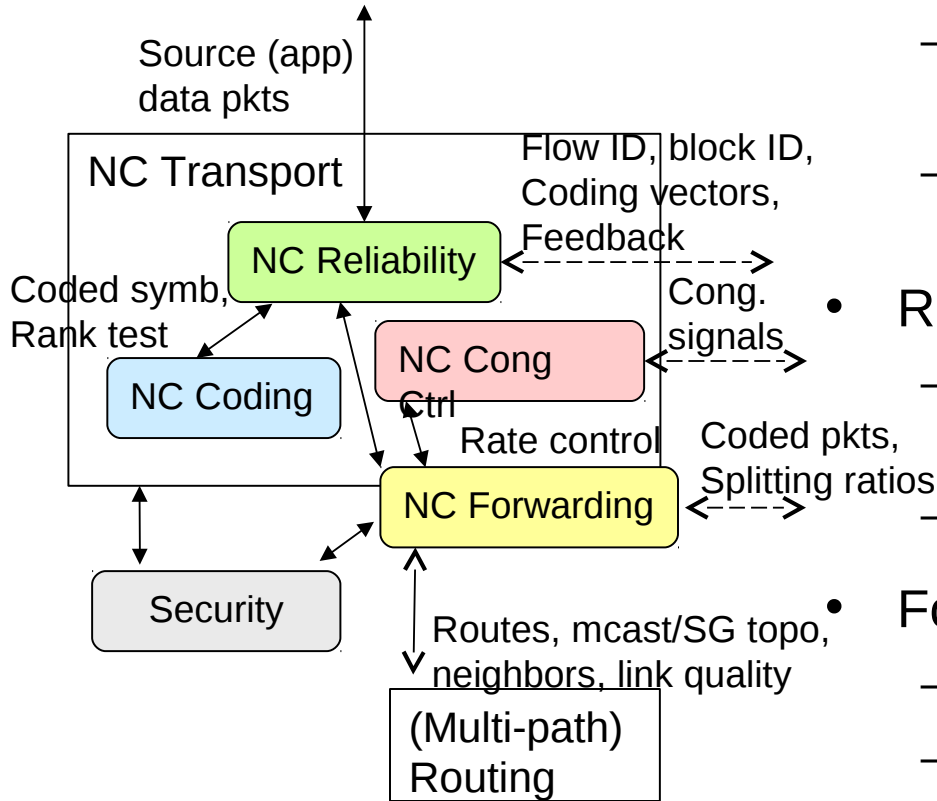
- Coding: end-end. Passes CC signaling.
- Optional: in-network re-coding.
- Coding nodes determined by: static configuration, routing or control signaling.
- Usage: reliability, similar to source coding.
- Security is a key building block factor – impacts all other BBs

Use Case 2: NC Transport, In-Network Coding



- Usage: reliability, resilience to link and node outage.
- Supports both Unicast and Multicast
- Assisted by multi-path (subgraph) routing
- Security is a key building block factor – impacts all other BBs

Network Coding Architecture: Functional Areas View

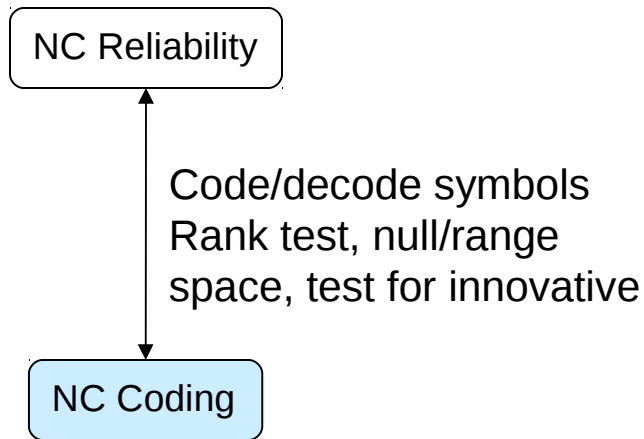


Considerations - Research

- Security: how to add encr, vulnerability
- Complexity, energy
- Heterogeneity

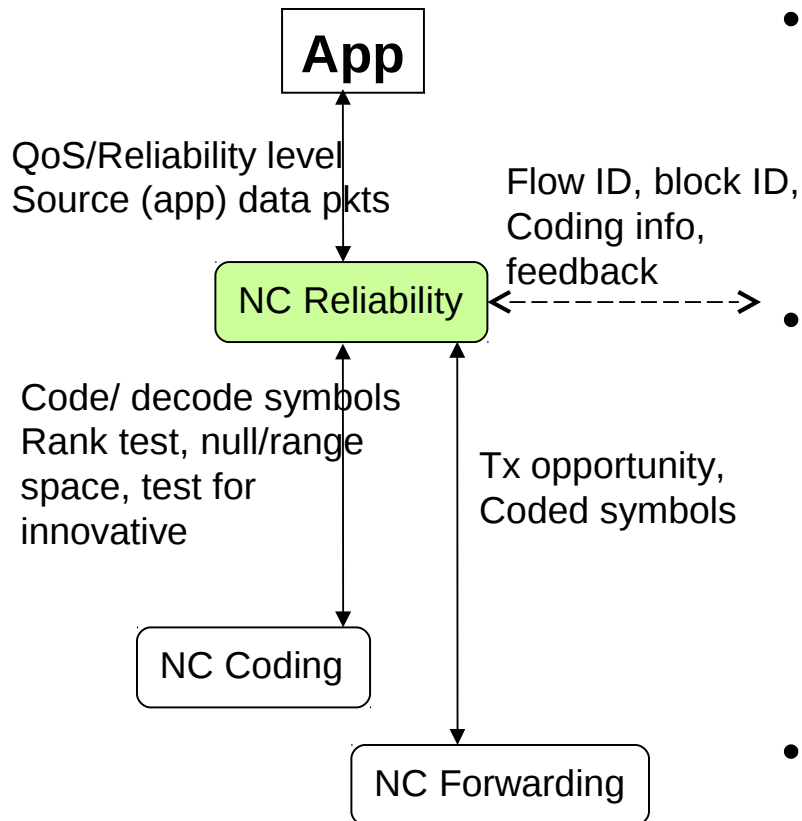
- Coding – all coding operations
 - Encoding, decoding, test for “innovative”, rank, null space
 - Uses operations such as finite field and linear transformations
- Reliability – algo & control for rel. transp.
 - Rel. logic: block, window, end-to-end, hop-by-hop
 - Ctrl: coding info (vectors, ID), feedback.
- Forwarding – Tx/Rx coded pkts
 - Pkt Tx logic: next hop, when to Tx
 - Ctrl: SG topo, splitting ratios/ fwd factors
- Cong Control – control of Tx rates
 - Ucast, mcast, **subgraph <research!>**
 - May use existing CC BB: TFRC [5348] for unicast, TFMCC [4654] for mcast.

NC Coding Functional Area



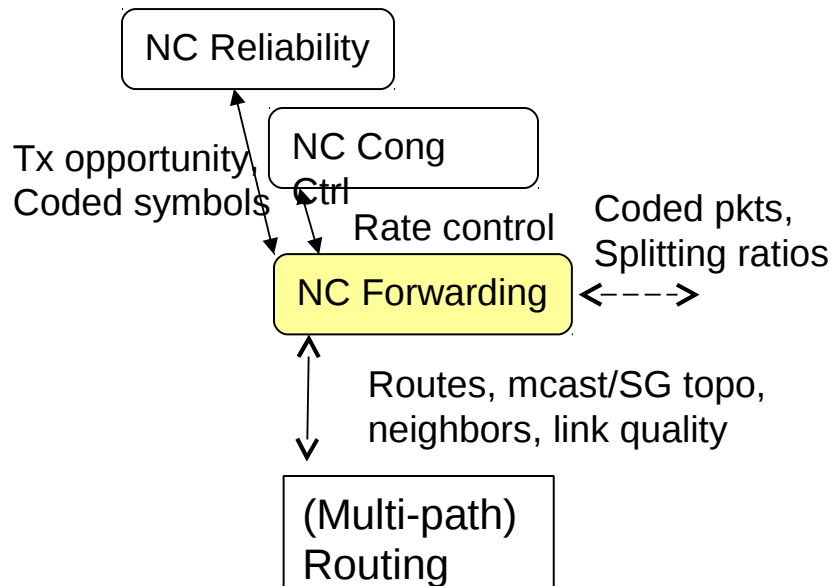
- Function: coding operations
 - Code/decode, test for block/gen rank, null space, window oper.
 - Test for innovative/ linear indep.
- Interfaces with Reliability FA
 - Request/provide coded/decoded symbols, block/window rank,
- No outside control

NC Reliability Functional Area



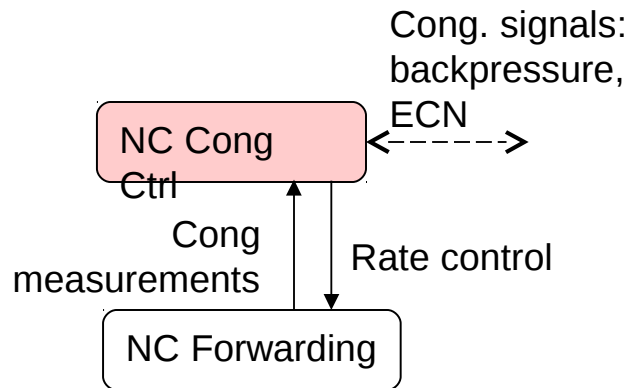
- Function: Reliable transport
 - Rel. logic: block, window, end-end/hop-hop
 - Manages flow of data/symbols between App, Coding, Fwd FAs
- Control: to Rel FA in peer nodes
 - Session: Flow ID, encoding type/ID, symbol size
 - Coding info: vectors, ID
 - Feedback: Block: rank/deg freedom/Null Space Sample; Window: high/low index
- Interface w Forwarding FA
 - Gets Tx opportunity
 - Provides coded symbols for Tx
- Interface w Coding FA
 - Requests coded/decoded symbols, req tests for rank, innovative

NC Forwarding Functional Area



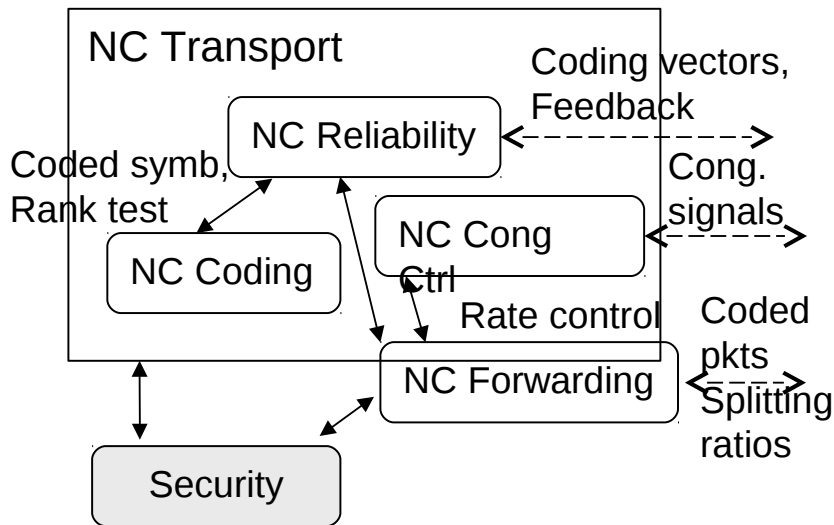
- Function: Tx/Rx coded pkts
 - Pkt Tx logic: next hop: neighbor nodes, when to Tx from what flow
 - Allocates flow slices to paths
 - Measures netw conditions: loss, delay
- Control: w Fwding FAs in peer nodes
 - Coordinate info flow allocation in multi-path/tree/subgraph: splitting ratios/ fwd factors
- Data plane: Tx/Rx pkts w coded symbols
- Interface w Congestion Control FA
 - Provides cong indications (loss, delay), gets Tx rate limit
- Interface w routing
 - Gets ucast/mcast/SG topology

NC Congestion Control Functional Area



- Function: control of Tx rates to avoid congestion and follow TCP-friendly recommendations
 - Ucast, mcast, **subgraph** <research!>
 - May use existing CC BB: TFRC [5348] for unicast, TFMCC [4654] for mcast
- Control: w CC FA in peer nodes
 - Congestion signals: backpressure, ECN, sliding window size
- Interface w Fwding FA
 - Gets cong measurements
 - Gives Tx rate limit

NC Security Functional Area



- Security Considerations:
 - How to add encryption: independent of coding or inter-changeable (e.g., homomorphic)
 - How to identify vulnerabilities
 - Different security mechanisms may apply to different FAs
 - Needs to be applied consistently across this complex system

Next Steps

- Draft on NC Architecture and Building Blocks
- Later, may need to split into separate BB drafts
- Try to reuse as much as possible: e.g., CC BB: TFRC [5348] for unicast, TFMCC [4654] for mcast
- Show how a simple protocol can be built with these building blocks