Network Coding Architecture Framework

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Network Coding Building Blocks

Buildings Blocks

Congestion Control Functional Area
- Back pressure?
- TFMCC?
- TCP-CC

Reliability Functional Area
- NACK
- NORM-NC
- Sliding Window
- Null Space Sample
- Knowledge vector

Security
- End-to-end feedback

Coding Functional Area
- Random Linear
- Deterministic
- Non-linear

Non-end-to-end feedback

Protocol Instantiations
- Dragoncast
- NORM-NC no recoding
- NORM-NC w recoding
- NCTCP
- CONCERT O/BRAVO
- NCTCP
- FECFrameV2
- Tetrys
- Others..
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

Building Blocks
- PGMCC*
- TFMCC
- WEBRC
- Coding Functional Area
  - FEC
  - Raptor, etc
  - Reed Solomon
  - LDPC

Reliability Functional Area
- TRACK*
- GRA*
- NACK
- LCT

Security

Congestion Control Functional Area

Protocol Instantiations
- NORM
- ALC

Applications
- FCAST
- FLUTE

* Unrealized building blocks
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

- **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!>

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

**Diagram Notes**

- NC Reliability
- NC Cong Ctrl
- Rate control
- Coded pkts, Splitting ratios
- Routes, mcast/SG topo, neighbors, link quality
- (Multi-path) Routing

- NC Forwarding
- Tx opportunity
- Coded symbols
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
• 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