Network Coding Taxonomy

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Overview

- Objective of document

  Describe the terminology and applicability of Network Coding techniques to network and content operations, as specifically related to different aspects of the Internet.
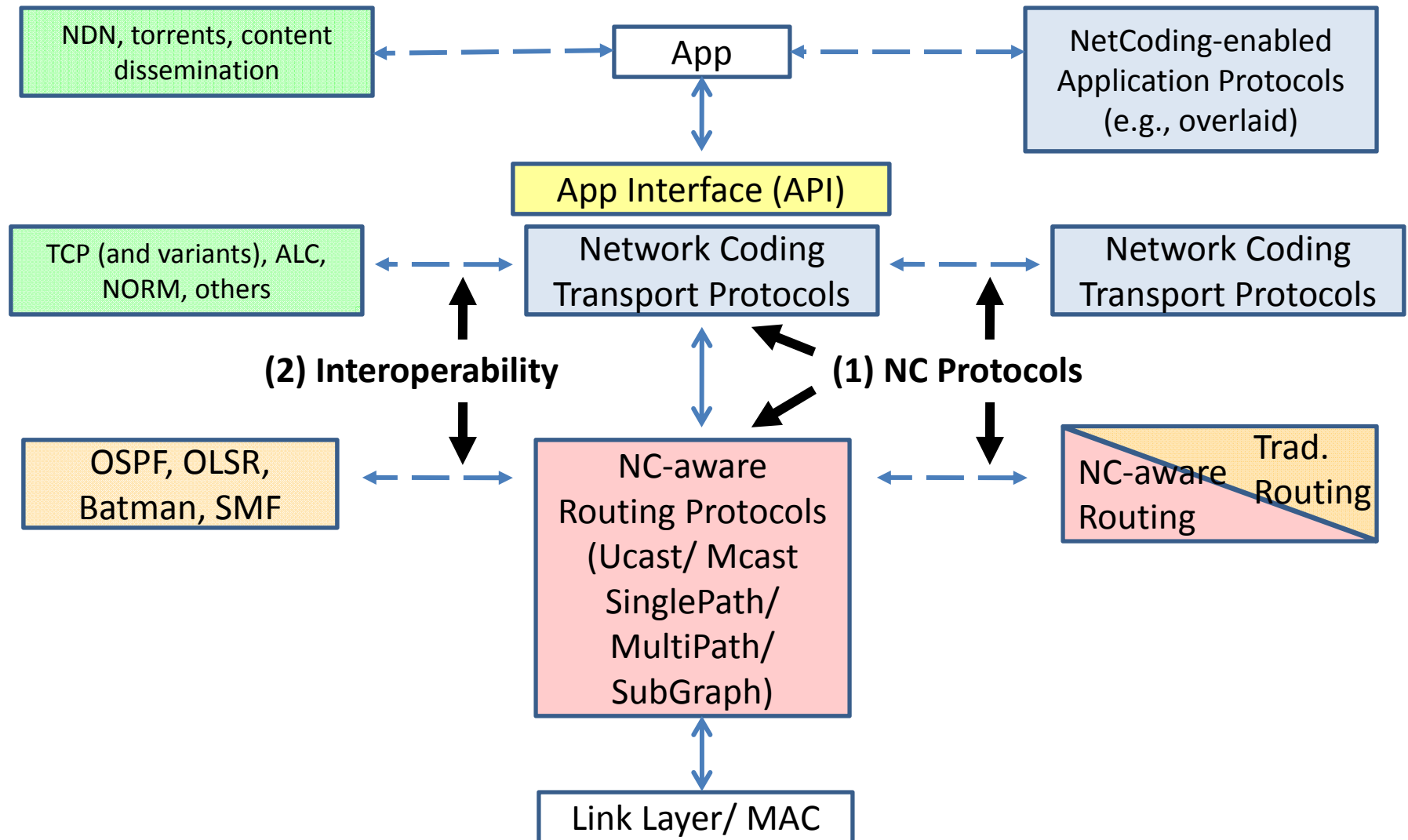
- Goal

  Identify and establish initial, commonly accepted (at least among the NWCRG participants) terminology and understanding of Network Coding principles and utility.
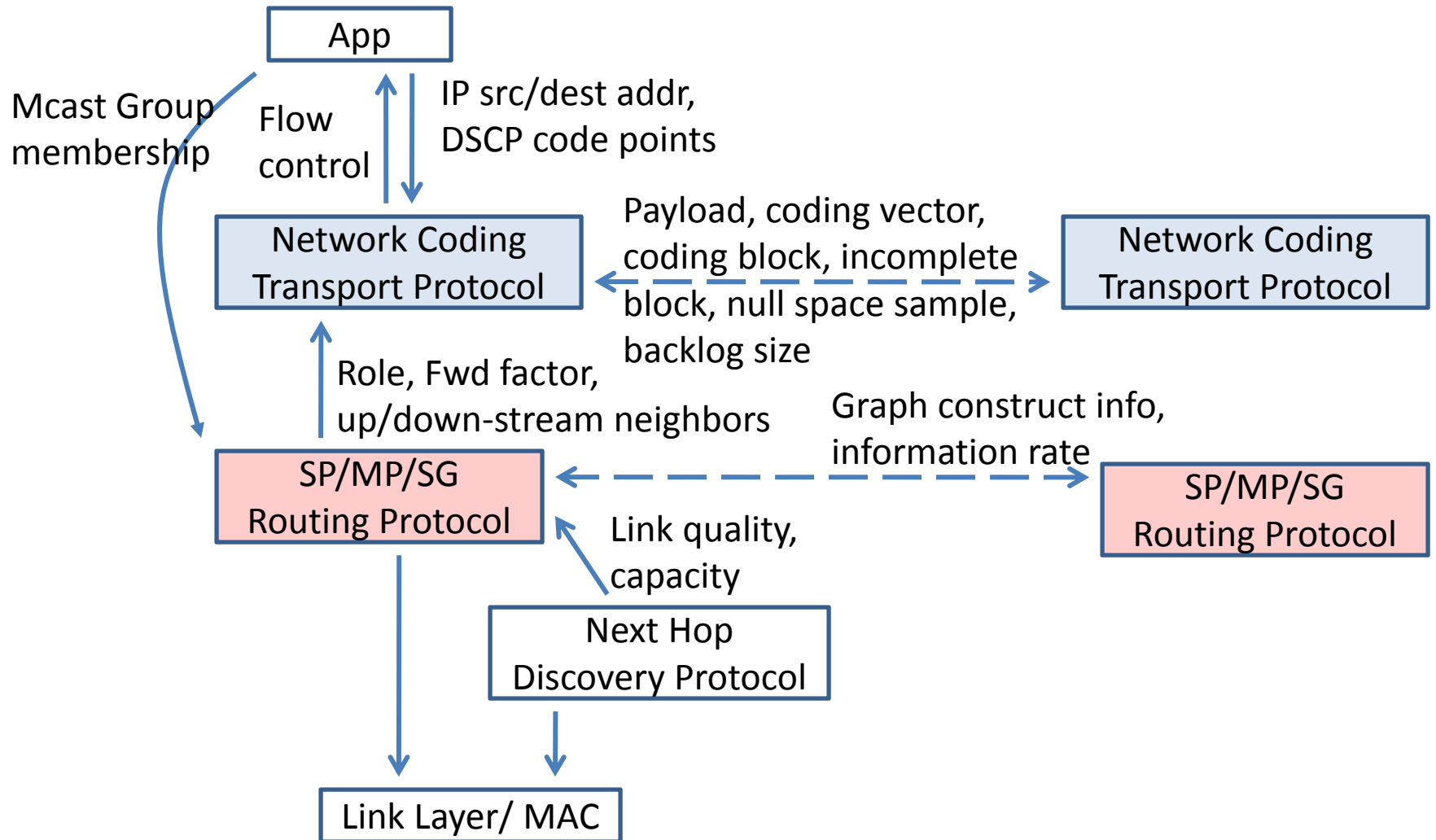
Areas of Terminology

- Payload-level Operations
- Node-local processing
- Routing and Forwarding
- Transport

Notional Network Coding Architecture

Notional Network Coding Protocols: Information Exchanges

Basics of Coding

- Coding Field

    A pre-defined finite field including all symbols used for coding in a given instance of a Network Coded data transport session. Fields have the desired property of having all elements invertible for + and * and all operations over any elements do not result in overflow/uderflow. Examples of finite fields are Galois fields, including $\{0..p^n-1\}$, where p is prime. Most used fields are $\{0..2^n-1\}$.

- (Coding) Symbols

    Elements of a pre-defined coding field.

Payload-level Operations

- Linear Coding

  Linear combination of a set of payloads using a given set of coefficients resulting in a coded payload. Payloads are divided in symbols over a Coding Field. Symbols at a given position from each payload are linearly combined. Resulting coded symbols are assembled in a coded payload, respecting the original in-payload order. All linear combinations on any symbol position use the same given set of coefficients. The input payloads may be application-original (not coded) or coded.

- Coding Vector

  A set of coding symbols representing coefficients needed for generating a given coded payload through linear coding of original (non-coded) payloads.

- Random Linear Coding

  Linear coding using a set of random symbols as coefficients

Payload-level Operations
in Block Coding Method

- **(Coding) Block**

  A set of (usually consecutive) application-level payloads defined by the sender-side of an NC transport protocol. Coding is only performed over payloads belonging to the same block. Payloads resulting from coding over payloads of a block, also belong to the same block.

- **Block size**

  The number of original payloads belonging to a coding block

- **(Coded) Payload Set**

  A set of payloads belonging to the same block, usually received at a node

- **Rank of a Payload Set**

  The number of linearly independent members of a Payload Set received at a node

- **Full Rank**

  The condition that a Payload Set received at a node has rank equal to the block's size. A Payload Set can be fully decoded into original packets iff it has full rank.

- **Partial Rank**

  Any rank that is less than full rank and not zero.

Node-local Processing

- Block NACK

  A message from a node that a given Payload Set does not have full rank

- Range Space – of a Payload Set

  The linear space defined by the coding vectors of a Payload Set

- Null Space

  The linear space that represents the complement of the Range Space of a Payload Set

- Null Space Sample

  A coding vector that is included in the Null Space

Network Coding Transport

- Flow

  A single data stream from a single source to one or multiple destinations

- Intra-flow coding

  Network coding over payloads belonging to the same Flow

- Inter-flow coding

  Network coding over payloads belonging to multiple Flows

- End-to-end coding

  Transport stream is coded and decoded at end-points

- Intermediate coding

  Packet coding can occur at endpoints and any intermediate nodes on the route

- Forwarding factor

  The rate of transmission from a node relative to the rate of information received at the same node

- Block Coding

  Original payload sequence is divided in blocks, and coding is performed only over payloads within a block.

- Sliding Window Coding

  Coding is performed over payloads in an interval of the original packet sequence, and the coding interval (window) is sliding over time.

Routing and Forwarding

- ## Single-Path route

  A route that has a single path from source to destination(s). In case of multicast, this is a tree.

- ## Multi-Path route

  A route containing multiple disjoint paths from source to a destination

- ## Subgraph

  A generalized multi-path route from a sender to one or multiple receivers where paths can intersect and diverge any number of times.

- ## Forwarding

  Process of conveying a flow from the current node or previous hop(s) to the next hop(s) along single- or multi-path routes

Other Considerations

- Network Coding as part of emerging new network paradigms?

  - Information Centric Networking (ICN)

  - Software Defined Networking (SDN)

  - Delay-tolerant Networking (DTN)

- When and where network coding makes sense and when and where it does not?