RMT and FecFrame Retrospective

Brian Adamson and Vincent Roca

IRTF Network Coding Research Group (proposed)

7 November 2013

IETF 88 - Vancouver

Purpose

- Review IETF Reliable Multicast Transport (RMT) and FecFrame working group activities
  - Use of packet erasure coding for reliable multicast or unicast transport
  - IRTF RMRG activities preceding RMT formation
  - RMT “Building Block” approach
  - Handling of IPR
  - Other protocol design considerations
  - Lesson learned along the way

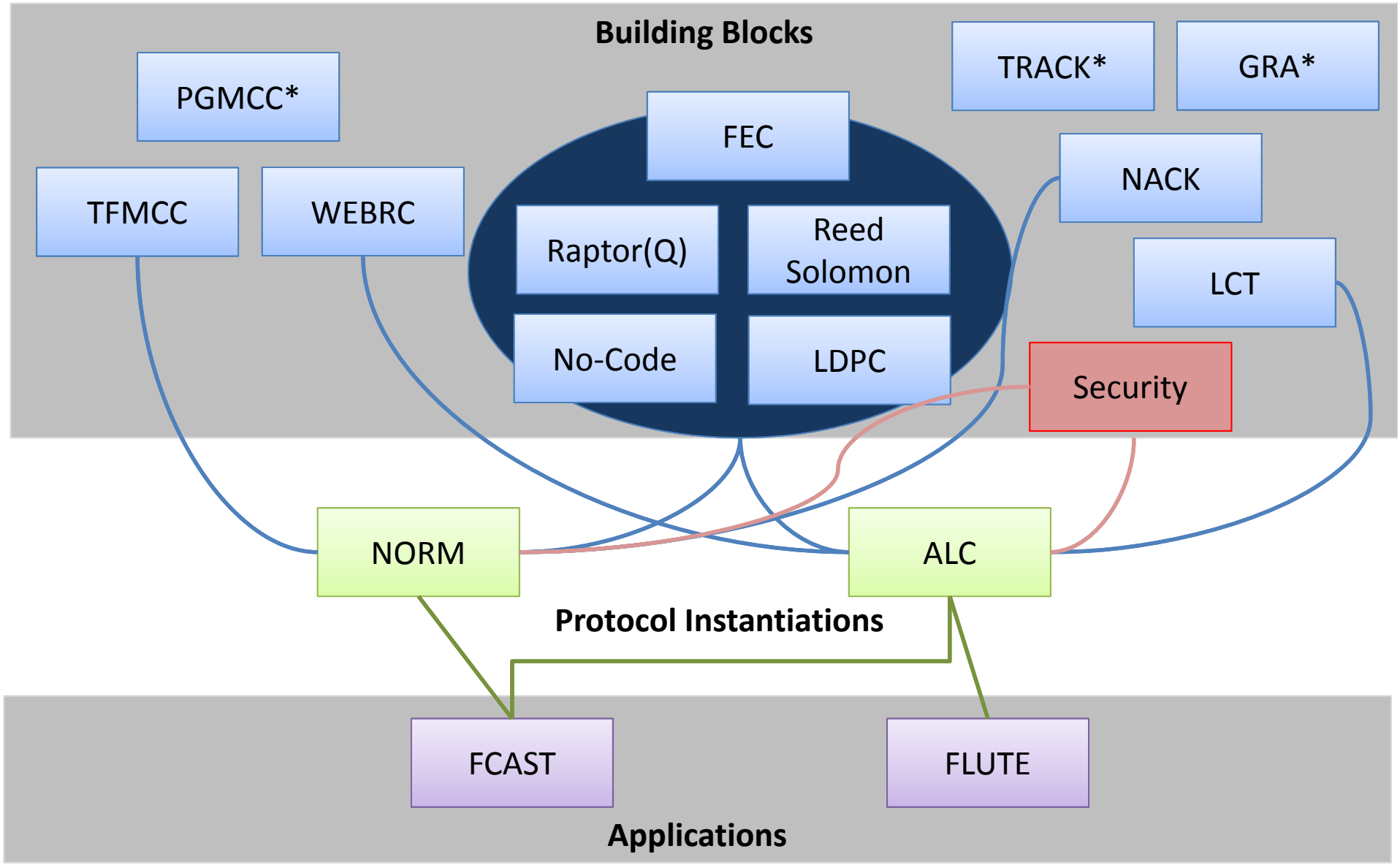
Some reliable multicast history …

- 1980's - Some pre-IP multicast work with broadcast ARQ using erasure coding frames
  - code combining, hybrid ARQ / FEC, etc at the MAC layer
- circa 1992 – MBONE leading to scalable reliable multicast (SRM) in wb tool, and Image Multicast (IMM), etc
- mid 1990's– many protocols emerging incl: MDP (from IMM), SRM, RMTP, MFTP, RMDP, PGM, etc
- 1996 – Packet erasure coding in reliable multicast (MDPv2, Luby Tornado code work, Rizzo's Reed-Solomon code work, first trickles of IP multicast data fountain concepts)
- 1997 – RMRG formation
- 1999 – RMT formation
- 2006 – FecFrame formation (unicast and multicast)
- 2013 – FecFrame closure, charter completed
- 2013 – RMT closure, charter completed

RMRG Activities

- Goals:
  - Determine scope and approach for appropriate reliable multicast standardization
  - Identify congestion control mechanism to enable Internet safe deployment of reliable multicast
- Results
  - Building block approach for family of protocols to provide “bulk transfer” delivery
    - NACK-based, Tree-based, and “open loop” FEC
  - TCP-Friendly multicast congestion control
    - Equation-based rate controlled TFMCC (DCCP variant)
    - PGMCC window controlled

RMT Building Block Approach



** Unrealized building blocks*

RMT Standards Track Protocols

- NORM
  - Bulk content objects and stream delivery including "message stream" feature
  - ARQ with/or FEC erasure coding repair
  - Single-rate TCP-Friendly and alternative congestion control options
  - Dynamically adapts to network with round-trip timing measurement to scale protocol timers
- ALC
  - "Open loop" FEC erasure coding reliability
  - Multi-rate congestion control support (still experimental)
  - Implementations available with low complexity Raptor(Q), Reed-Solomon and LDPC codecs

Separable Protocol Aspects

- For example, different aspects of NORM are separable and even “pluggable”
  - Reliability
    - FEC type and parameters
    - Proactive FEC only (no receiver feedback, like ALC)
    - Hybrid reactive / proactive ARQ and FEC
  - Congestion Control
    - Fixed-rate operation
    - TCP-Friendly NORM-CC (NORM TFMCC realization)
    - Other (e.g. experimental ECN-based NORM-CCE)
  - Flow Control
    - Explicit (e.g. ACK-based)
    - Implicit (e.g. timer/NACK-activity based)
    - Disabled (e.g. real-time flows)
- And it’s the same with ALC …

Case study: FEC Building Blocks

- Standardized code point identifiers for FEC algorithm type
- Standardized FEC packet payload identification (FPI)
  - `objectId:blockId:segmentId` tuple
  - "in transit" identifier only
- Standardized FEC Object Transport Information (OTI)
  - Object size, encoding scheme and parameters
  - Multiple means to convey information to participants

RMT deployments

- FLUTE/ALC
  - 3GPP-MBMS (Multimedia Broadcast and Multicast Services) and similar standards
    - integrate FLUTE/ALC
    - integrate Raptor / Raptor(Q)
    - ISDB-Tmm integrates LDPC-Staircase
- NORM
  - Multiple US government / DoD uses
  - CATV video on demand content distribution

RMT outputs are widely deployed and used worldwide ☺

FecFrame Working Group

- Design a framework to enable the application of FEC codes to arbitrary packet flows over unreliable transport protocols, in unicast or multicast
  - main use cases are for continuous media flows
- midway between RTP and RMT work
  - RTP offers limited FEC support… FecFrame goes much father
  - inherits from RMT many concepts and FEC code specifications

FecFrame outputs

- FecFrame architecture (RFC 6363)
- several FEC schemes:
  - Raptor(Q), Reed-Solomon, LDPC, 1-D interleaved XOR
- signaling docs
  - configuration, SDP, pseudo-CDP
- FecFrame included inside the 3GPP-MBMS standard

Intellectual Property Rights

- The building block approach enabled some management of IPR issues
- Some FEC code types had IPR disclosures, but (mostly) the protocol mechanisms were clear of IPR
- FEC codecs treated similar to multimedia (i.e. voice, video) codecs

  Thus, IPR becomes mostly an implementation detail and choice.
- IETF handling of IPR disclosure worked fairly well
  - *several constructive IPR discussions took place and enabled to clarify the situation*

Some lessons learned

- Building block approach was beneficial
  - MANET WG has adopted similar approach for its standards track protocols
- Common packet formats for ALC and NORM would have been nice
  - however compatible header extension concepts in both families enable some reuses
- End system node identification challenge
  - NORM uses something like RTP “SSRC” identifier but more flexible approach would be beneficial
- Benefits of RMT protocols for unicast use cases have been surprising

Some unfinished business …

- Unequal error protection concepts introduced towards end of working group activities
- Potential for some additional congestion control specifications (e.g. NORM-CCE)
- Additional FEC schemes?
- Distributed session management / control

Some of the same concepts can be re-applied at other protocol layers (application, forwarding, etc) as part of a more encompassing network coding strategy