

Enhancing the Internet Network layer with
Hints and Notifications

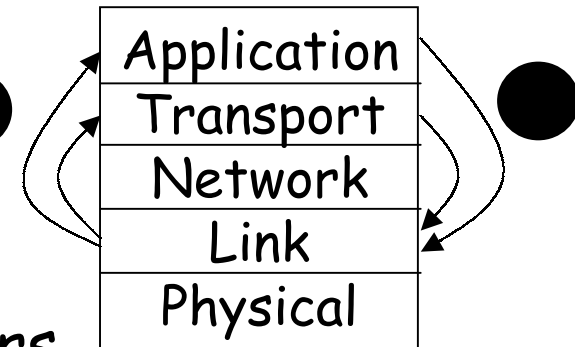
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Context

- **Aim**: Optimize wireless link utilization and utility for users of **Internet** applications
- This requires knowledge of:
 - data properties and service demands in the link layer
 - current wireless link conditions in transport and application layers
- **Problem**: Internet layering principles do not allow inter-layer communication



Demands

- Error resilient (real-time) applications
 - Payload properties unknown at the link layer
 - Link properties unknown to applications
- Joint source and channel coding
 - Beneficial at high bit-error rates (wireless)
- Unequal Error Protection (UEP)
 - Source Significance Information (SSI)
 - UEP capabilities influence choice of source encoder
 - E.g., progressive encoding needs bit-errors to be pushed towards the end of each packet's payload
 - Non-uniform bit-energy distributions (e.g., HQAM)

Demands, cont.

- Source controlled channel encoding
 - Source A-priori Information (SAI)
 - Probability of the value of next bit to decode
 - For source coding schemes using a frame format several coded pixels in an image are put in the same frame, resulting in bits being correlated within frames
- Assumption:
 - Introducing mechanisms for inter-layer communication encourages development of voice/video applications for the Internet that are based on **joint source and channel coding**

Transport

- New UDP (formerly named UDP Lite)
 - Specify part of a packet as less sensitive to bit-errors (disable the checksum for that part)
 - Avoids unnecessary packet drops for applications that are resilient to bit-errors
- Datagram Control Protocol (DCP)
 - As for new UDP, checksum coverage is selectable
- New protocols supporting different joint source and channel coding schemes (?)

Network layer Hints

- Without hints . . . layer violation . . .
 - Link layers need to examine UDP, DCP, and (?) headers to optimize bandwidth utilization
- Trading higher delay for lower error-rate
 - UDP and DCP headers do not however carry information about delay requirements
- Simple hints include information about:
 - Boundaries between parts of a packet
 - Acceptable error-rate for each part
 - Delay requirements for each part

Demands, cont.

- Congestion-responsive applications
 - Packet loss may be misinterpreted
 - Delay in detecting connectivity
- TCP tweaks for wireless links
 - Numerous tweaks have been proposed to improve the operation of TCP over wireless links
 - Packet loss due to bit-errors:
I-TCP, MTCP, M-TCP, Snoop, DDA, TULIP, . . .
 - Temporary disconnected wireless hosts:
Freeze-TCP, TCP-Probing, . . .

Network layer Feedback

- Goel and Sanghi: two new ICMP messages
 - Informing TCP sources of packet delay and packet loss caused by bit-errors
 - Sent for all packets facing these problems
- HAN generalize this approach
 - Limits traffic and enables accurate feedback by requiring messages to be explicitly requested (i.e., through hints)
 - Allows for more messages and divides them into two different types (action and status)

Notifications

- Link action notifications (feedback type 1)
 - Origin from link actions associated with individual data packets for which feedback is explicitly requested in hints, e.g.:
 - Packet delayed due to;
 - local retransmissions (G&S), or
 - that the wireless link is disconnected (new)
 - Packet dropped due to;
 - bit-errors (G&S) or temporary congestion (new),
 - persistent congestion (new), or
 - that the wireless link is disconnected (new)

Notifications, cont.

- Link status notifications (feedback type 2)
 - Static and dynamic information sent for every individual request made with hints (all new), e.g.:
 - UEP capabilities, need for SAI, etc.
 - Still disconnected, or connection re-established
 - Currently available bit-rate
 - Select initial sending rate after re-establishment
 - Maximum available bit-rate
 - Complement to probing for available rate (limits cwnd)
 - Average error-rate
 - Enables selection of sufficient codec (e.g., voice)

HAN

- Enhances the network layer with additional functionality (avoid layer violations)
 - Makes IP more "wireless friendly"
- Deployment of HAN
 - Hints can be used without notifications
 - Notifications need hints, or a similar mechanism
 - Widespread usage of hints would make the concept of notifications attractive
 - Make HAN optional and backwards compatible
 - Enable immediate and partial deployment

Implementation

- IP options as Hints
 - Nodes capable of parsing hints do so, other nodes just forwards them intact
 - Processing overhead is an important issue (slow-path processing)
- ICMP messages as Notifications
 - No new protocol needs to be invented
 - ICMP already has a "notification" message (source quench)
- Other alternatives ?!

Concluding remark

- HAN should not (and cannot) aim at solving **all possible needs** related to inter-layer communication for wireless networking
- It can however give **basic assistance** in meeting such needs, enabling improved operation of **different applications** over wireless networks

Questions?