Modem Link-Property
Advertisements

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Cognitive Networks and Radios

• **Autonomous system** – perceives current conditions, and then plans, decides, and acts on those conditions based on predefined rules and algorithms.

• **Cognitive system** – **LEARNS** from the consequences of its actions and uses this knowledge to improve the future decisions (instead of just predefined rules/algorithms)
  - Feedback is required
  - Need to establish good metrics
  - Learning takes time

• Radio Networks should be cognitive for true adaptability and dynamism and be aware of its environment.
  - Thus, technologies must be developed that expose radio parameters to rest of network and provide methods for adjusting those parameters.
    - Example - Modem Link-Property Advertisements
Smart Modems

- Modem's transmitting and receiving link rates can be varied over time due to the following:
  - Adaptive coding
  - Changes in Modulation to suit radio channel characteristics.
  - Changes in transmission rate to suit radio channel characteristics
- Rate mismatch between RF link and Ethernet link.
  - Serial connections are less of a problem as clocks can be controlled by modem (at least the receiving clock)
  - Ethernet connections are becoming standard and result in rate mismatch between the LAN interface and the RF link.
To condition traffic and get the most out of the modem's link capacity, routers & applications need to know the modem's link conditions.  
- Figure 1 corresponds to existing commercial imaging satellites  
- Figure 2 is more generic

Desire is to have a standard method for the upstream devices (router and host applications) to learn of the link conditions and adjust
- Link Up/Down
- Link Unreliable
- Data Rates

**Figure 1**

RF 3 Mbps  
Modem  
Serial Link  
Application

**Figure 2**

RF 3 Mbps  
Modem  
Ethernet 100 Mbps  
Ethernet 1 Gbps  
Application
Solution

- Develop a standard protocol that provides link status conditions
  - Should be able to provide wide area network (WAN) radio reachback link status to routers and upstream devices/applications that may be multiple hops away.

- Uses
  - Applications can adjust to link state
  - Route Optimization
    - Useful for multi-homed systems

![Diagram showing network connections and data rates]
Crypto/Router

- Red/Black Separation
- Rate Mismatch Problem
- It is hard to sense the real rates offered through “the system”.
  - It is feasible for such devices to work this out on their black side - and the red side and can simply advertise the "offered rate".
  - The Black side obtains knowledge of its downstream link state via modem advertisements, router advertisements, or probes, and pass this on to the red side via approved methods.
  - The red side can then advertise its rate via the LPA protocol.

![Diagram showing Crypto and Ethernet connections with effective throughput and Ethernet speeds](diagram.png)
Strategy

- Released public request for participation to radio system providers and information system manufacturers

Starting Points
- RFC-5578, PPP over Ethernet (PPPoE) Extensions for Credit Flow and Link Metrics
  - Informative Document
  - Similar idea, but very complex with too many parameters that cannot be set well.
- Dynamic Link Exchange Protocol (DLEP) (draft-ietf-manet-dlep-00)
  - Similar to RFC-5578, but does not utilize PPPoE
  - Router-centric
  - Session-oriented
- Link properties advertisement from modem to router (draft-wood-dna-link-properties-advertisement-01)
  - Uses UDP multicast to advertise link characteristics
  - Simple

Demonstrate usability in C or C++ implementation of Saratoga
- Listen for information on multicast channel to set rate-limit
- Can test in Global Hawk Protocol Testbed.
Protocol Concepts

• Advertise Modem’s link conditions over IP/UDP
  – Link-local IP multicast advertisements from Modem
    • No need for client/server configurations
    • Requires no explicit configuration setup to provide information to connected devices.
    • Easy to deploy
• Advertise link properties to upstream systems.
  – IPv4 organizational-scoped multicast and IPv6 site-local multicast
    • Requires multicast to be enabled in network
    • Requires approval of a new organizational/site-local multicast type by the Internet Assigned Number Authority (IANA).
    • Misconfigurations of organizational-scoped or site-local multicast could result in advertisements in unforeseen global traffic.
  – Unicast advertisements
    • Requires configuration in the modem to send advertisements to known endpoints.
Protocol Signaling

• Advertisements are sent periodically or as notifications of link-layer events (such as rate changes) when they happen
  – A link rate changes due to a coding change, or the link and its interface go up or down
• The modem should send periodic advertisements about link conditions, in case new devices have been connected
• A device attached to the local link must be able to receive link property advertisements via UDP/IP packets sent to the "all routers" multicast address.
• Other network-attached devices may receive advertisements via IPv4 organizational-scoped multicast and IPv6 site-local multicast or unicast advertisements.
Protocol Block Type

1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| UDP source port | UDP destination port |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| UDP length | UDP checksum |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| Block Type ID (Rate Type 1) | Length |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| no. of links | link rate size| modem flags (15 bits unused)|S| |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| unique modem interface identifier |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| MTU | interface flags |B|F|4|6|U|I|S|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| current link rate (varies) - 32 bits is rate size of 1 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| minimum supported rate - 32 bits is rate size of 1 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| maximum supported rate - 32 bits is rate size of 1 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| IPv4 address of modem's local link interface, if 4 flag set |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
| IPv6 address of modem's local link interface, if 6 flag set |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
Rate Block

• Currently, only one Block Type has been considered, the Rate Block [Slide 11]. Key components of this block type are:
  – The maximum data rate is defined by a 32-bit word corresponding to a limit of 4 Gbps.
  – This format enables one to specify link characteristics simultaneously for both link directions, or separately for the incoming and outgoing links.
  – Link Up / Link Down information is conveyed via the interface flag “U”.

• Other possible blocks, not yet defined here, could express measured error rate, current forward error-coding rate, latency (propagation delay, serialization delay), link MTU size, indicate link-level security mechanisms in use, or provide authentication.
Status

- Internet Draft submitted to Mobile Operations research group (mobopts)
  - Modem Link Properties Advertisement Protocol
    (draft-ivancic-mobopts-modemlpa-00)
    expires April 16, 2012
  - Why mobopts ➔ One research topic is to examination of the feasibility of generic mechanisms that allow tighter integration of the link layer with the IP layer for improving handover performance
  - Mobopts has not been very active lately and may rechart, but, this appears to be the most appropriate place to perform this activity
Collaborations

• Anyone or any organization interested in collaborating is welcome – particularly radio developers.

• Google Groups “modemLPA” formed
  – Maillist and archive
  – 13 current members
  – Open to any interested people
    • Contact Will Ivancic (william.d.ivancic@nasa.gov)

• Working with University of Akron
  – Packet Generation of modemLPA protocol for testing
  – Dissector for Wireshark®
  – Possible additions to NASA PERL implementation of *Saratoga*

• Working with Dr. Shaoen Wu of the University of Southern Mississippi
  – Rate Adaptation on Random Access Wireless Networking
  – Cognitive Wireless Networking Protocols
Summary

• We have presented a simple protocol that can be used to provide upstream devices and applications with downstream link conditions.

• The protocol in this document is described in the context of modem RF link properties, but can also be broadly applied to other scenarios such as cryptographic devices.

• The ability to sense and react to such information is critical for new and developing technologies such as cognitive radios and cognitive networks.