Naming, Addressing and Routing in Delay-Tolerant Networks

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Outline

• Why DTN?
• Become a DTN expert in 10 minutes (or less!)
• Naming, addressing, and routing in DTN
• Case study: DTN for rural kiosks
Why DTN?

- Provides communication in *challenged environments*
  - Outer space, sensor, vehicular, underwater, rural, or highly-mobile networks
- Reduces *cost*
  - By exploiting cost-delay tradeoff
- Increases *robustness*
  - To wireless-coverage holes and network flakiness
- Allows exploration of networking *fundamentals*
  - Opens fundamentally new modes for naming, addressing, and routing
DTN in a nutshell

- Delay- and disruption-tolerant interoperable networking
- Both ends are not simultaneously present
  - Can’t use end-to-end TCP/IP
  - Need to store and forward
- Time-varying topology
  - Routing can be complex
  - May need to send multiple copies
- Interoperable => overlay
Contexts

- Drive-by vehicular
  - Infostation, Drive-Thru Internet, ...
- ‘Nodes in a box’
  - Mobile Ad Hoc Networks
  - Haggle, Zebranet, SWIM ...
- Deep space
  - Precise schedules (NASA/JPL)
- Challenged links (‘Flakynet’)
  - Remote or developing regions (Tier, Seismic monitoring, UUCP...)
- Ferry-based
  - Hybrid between MANET and Deep Space
Basic idea

Sender

Receiver

DTN Overlay

DTN router
Architectural elements

- Variable-length **bundles**
- overlaid on multiple protocols (like IP on frame) by means of **convergence layer**
- large enough to amortize costs for lookup and authentication
- **DTN nodes**
  - an element that implements the bundle layer
  - participates in hop by hop transfer of bundles
Elements (contd.)

- **Links** are not always available: an available link is a **contact**
  - persistent
  - on-demand
  - intermittent
    - scheduled
    - opportunistic
    - predicted
- **Network** is a directed **time-varying multigraph**
- **Late binding** of paths to destinations
Elements

- Some nodes are custodians that promise to save bundles in persistent storage
- (potentially) commit data to a database using a transaction
- remove data either when delivered or when custody has been transferred
- Hop-by-hop and end to end signaling (like ICMP) to optionally indicate bundle progress and receipt
Node naming/addressing

Nodes

Endpoints

Persistent Registration

Application

BPA

CL CL CL

EIDs are RFC 3986 URIs

<scheme>://<ssi>

EID1

EID2

EID3

EID4

EIDs are RFC 3986 URIs

<scheme>://<ssi>
Forwarding

- Name-based forwarding (name = address)
- Late-bound
  - exploit new paths as they come up
Routing

- An open problem
- Solutions depend on the underlying system assumptions
  - ‘Nodes in a box’: opportunistic, epidemic
  - Deep space: exploit precise schedules
  - Infostation: exploits Internet availability
  - ‘Flakynet’: can use traditional link state
  - Ferry-based: combines opportunistic and scheduled
Mechanical backhaul
Kiosk
Gateway
Simple backhaul
Generalized backhaul
Solution features

- Exploit **Internet as a backbone**
  - Concept of a time varying multigraph is too general
- DTN node is a kiosk, bus, or gateway
- **Mobility** support
- Infrastructure to **allocate and manage endpoint IDs**
- Extensive **application support**
- Efficient **link detection**
Kiosk
Internet
DHT Overlay
Receiver at R-1
Receiver at R-2
Bus
DHT has mapping from GUID to destination region
Bus/Kiosk
Gateway
Nodes identified by GUID = Public key = SHA1(human readable name)
Kiosk
Kiosk

DHT has mapping from GUID to destination region

Nodes identified by GUID = Public key = SHA1(human readable name)
Details

- EID is a GUID is a public key
  - Separates address from location (like HIP or DOA semantic-free identifiers)
  - GUID is SHA1 hash of email address or IMSI
- Late-bound bundles
  - Lookup in the forwarding path
  - Allows disconnected endpoints that cannot do DNS
- DHT for location management
  - Makes lookup scaleable and robust
  - Leverages current research in DHT (caching, efficient search etc.)
- Reverse Path Forwarding or flooding for local routing
  - Simple, stable, and self-configuring
- Bundle relocation
Conclusions

- DTN is an interesting technology for several non-traditional environments
- Novel algorithms and concepts for naming, addressing, and routing
- Our work addresses these concepts for low-cost rural networking
- Many other open issues remain!