

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

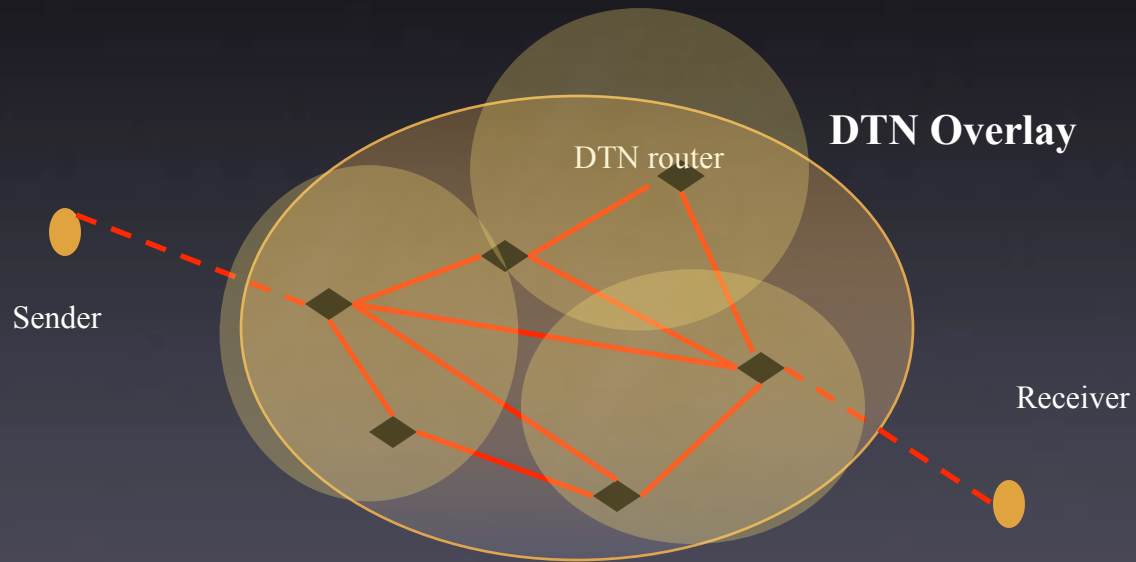
DTN in a nutshell

- 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
 - Huggle, 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



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

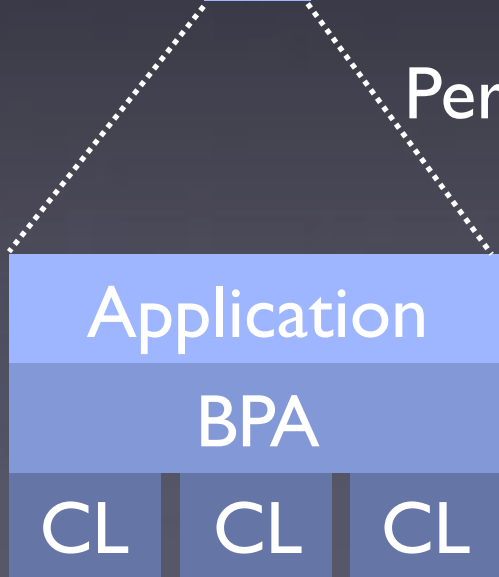
Node naming/addressing

Nodes

Endpoints



Persistent Registration



EIDs are RFC 3986 URIs
<scheme>://<ssi>

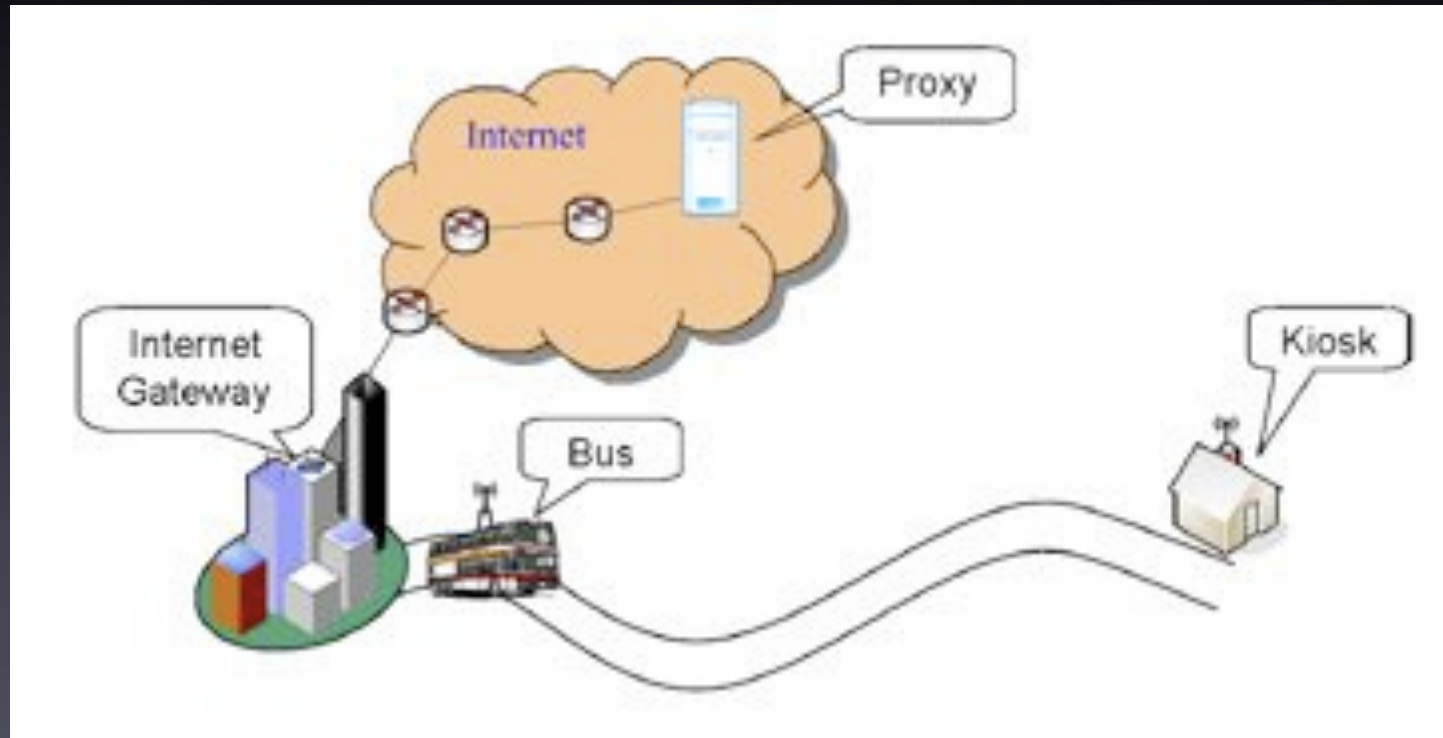
Forwarding

- 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



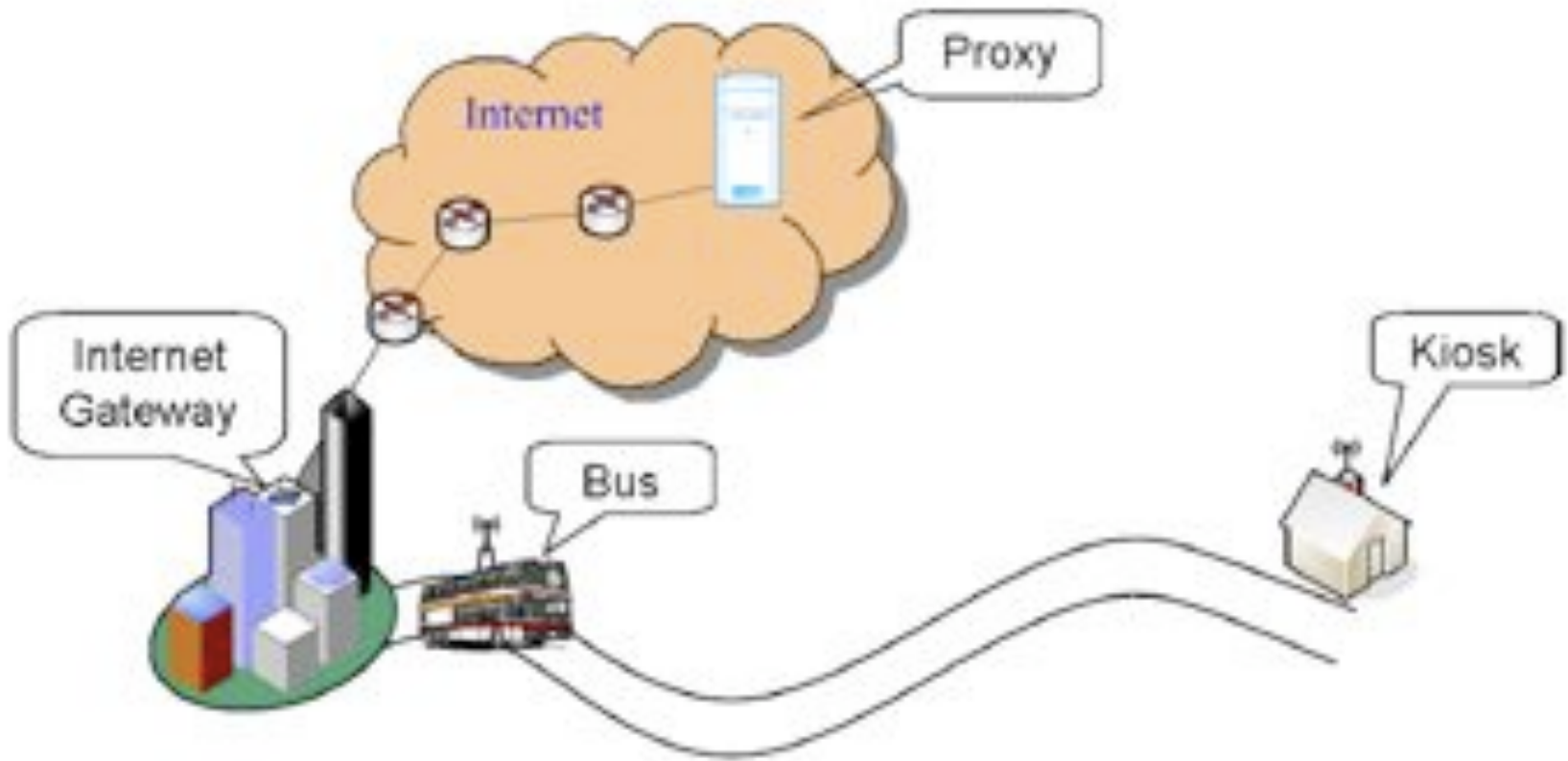
Ferry



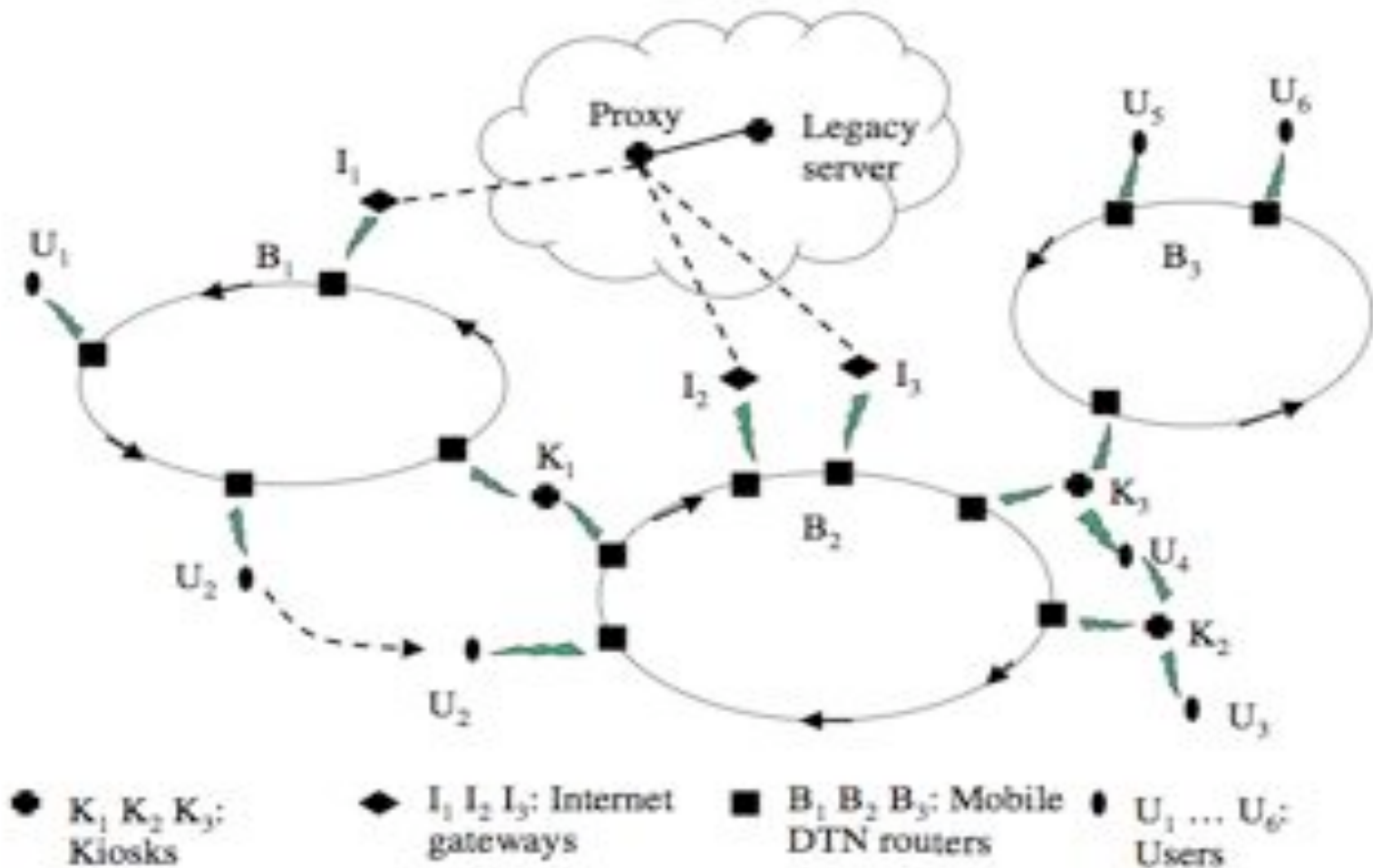
Gateway



Simple backhaul

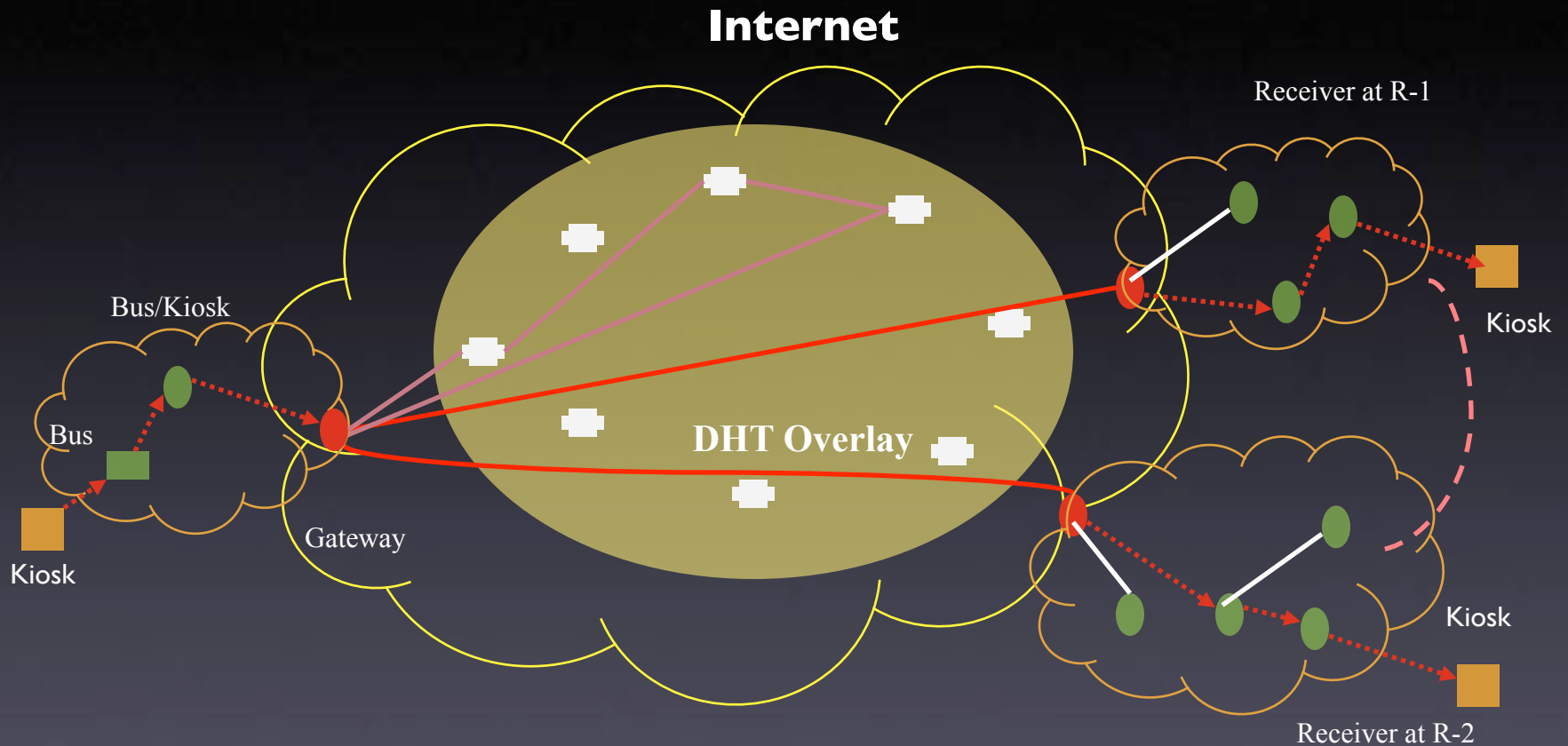


Generalized backhaul



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**



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!