SPINDLE-II Project Overview

Disruption-Tolerant Networking R&D at BBN

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BBN SPINDLE-II Project Team

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IETF-67

November 9, 2006

BBN TECHNOLOGIES

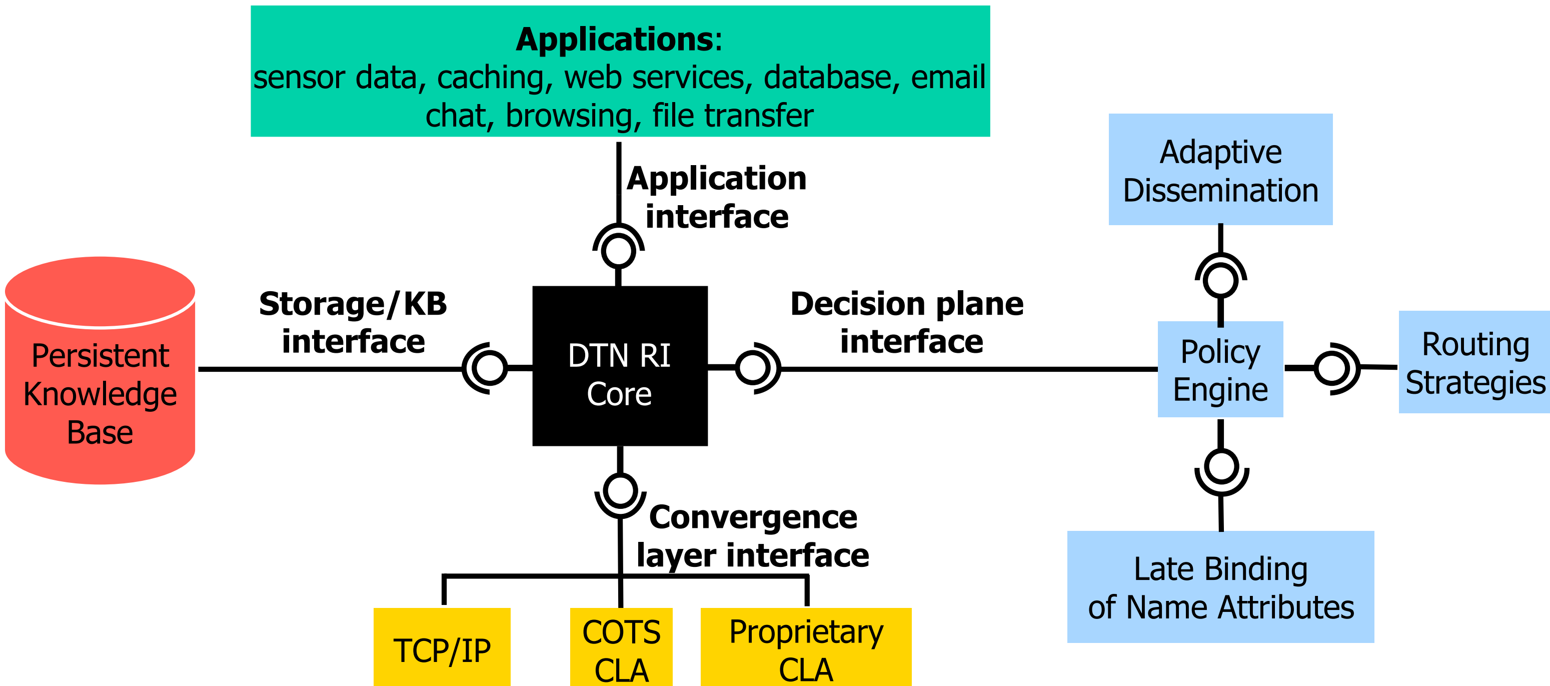
Outline

- BBN's SPINDLE-II project
- A declarative knowledge-based approach to DTN
- Late binding of intentional names for endpoints
- Disruption-tolerant access to content
- Routing, network state dissemination, and policy support

BBN's SPINDLE-II project

- System Research and Development "thread"
  - Led by Christopher Small.
  - Working with DTN RI (DTN2) developer community.
  - Completing missing features.
  - Adding to testing infrastructure, doing scalability testing.
  - Designing and implementing plug-in framework.
  - Documenting internal and external interfaces.
- Technology Innovation "thread"
  - Led by Prithwish Basu.
  - Balance of talk is about SPINDLE-II research.

SPINDLE-II
DTN RI architecture + plug-ins



- DTN RI core platform: open source
- Plug-ins: open source or proprietary
  - convergence layers, storage/KB, routing, naming

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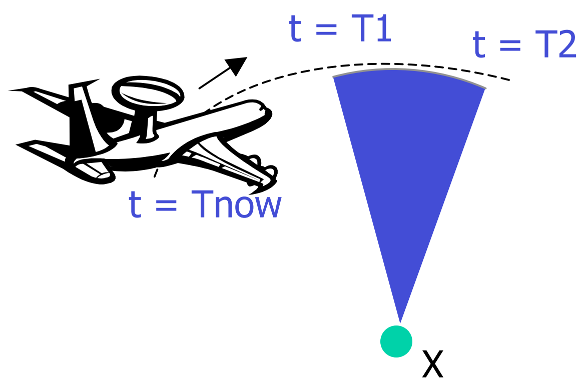
A declarative knowledge-based DTN

- Knowledge bases offer flexible, extensible framework
  - Use inference to derive new facts from simpler facts.
  - Offer uniform query interface for explicit and derived facts.
  - Perform decision making and search of dynamic facts/rules.
  - Support rapid prototyping, deployment of new capabilities.

- Integrated declarative routing, naming, and policy
  - Approach extends naturally to content-based networking.

Specifying rich DTN information

Example: inference rules for link formation



Ground node X infers a predictedLink for plane, given its trajectory information. Prediction is useful as plane is in range too short a time for traditional network topology discovery.

- Rule to predicted link:

  predictedLink :: spindleLink.
  S : predictedLink [from→X, to→plane, upAt→T1, downAt→T2] :-
  plane [trajectory→Trj1], X [trajectory→Trj2], walltime (Tnow),
  trajectory_crossing (Tnow, Trj1, Trj2, [T1, T2]).

- KB contents can be shared, for informed routing decisions
  - forwarding, routing, and other decisions based on queries into the KB

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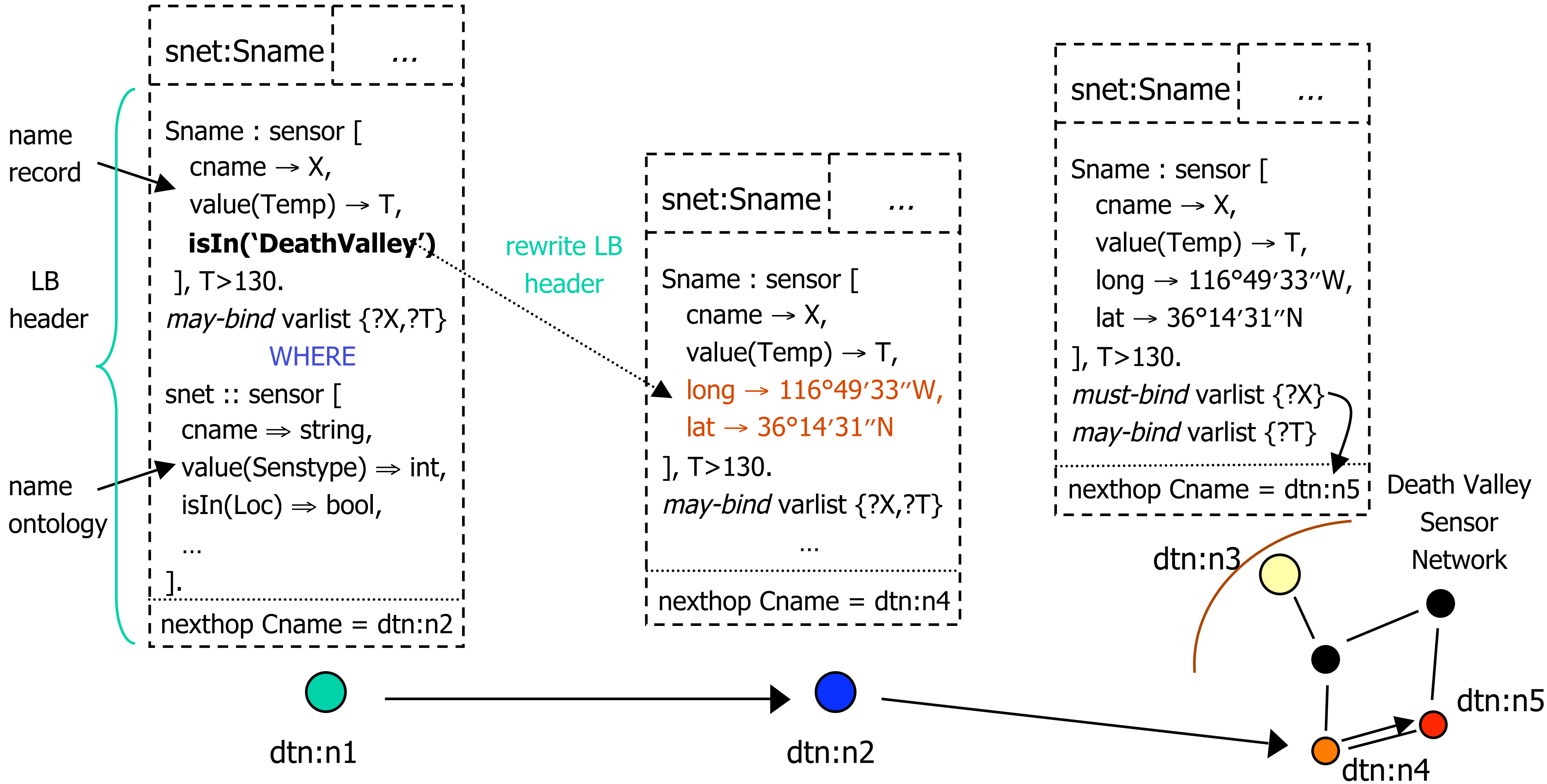
Late binding of intensional names

- *Intensional* naming is via attributes, not identity:
  - Canonical name: Christopher.Small@bbn.com
  - Intentional name: techLead@{org=BBN,proj=SPINDLE-II,thread=dev}.
- Disruption-tolerant network often needs late name resolution
  - Final destination not known at the originator.
  - Destination learned progressively within the network.
- Mapping of names from a rich namespace to routable endpoints
  - Extensible ontology to express multi-attributed intentional names.
  - Protocols to maintain name KBs and progressive resolution within network.
- Defer binding of next hop to convergence layer address and parameters
  - Capability for several communication modes (e.g., WiFi, GPRS, ...) may exist.
  - Parameters (address, protocol, data rate) may be negotiated on contact.
  - Can route with only coarse-grained information about future adjacencies.

Progressive resolution of attributes

Endpoint Names As Queries



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Disruption-tolerant access to content

- Boy Scout troop 47 is hiking through woods, led by Scout Master Chuck, who has maps of planned route on his PDA.
- Scout Master Chuck is lousy guide, and gets troop lost in the woods. He requests new maps from Google.
- Internet scenario:
  - Chuck is off the net, TCP connection request fails, no maps.
  - Scout troop stays lost until discovered days later by Ranger Rick.
- DTN scenario:
  - Request sent to local nodes (PDAs, iPods, etc.), and stay there.
  - Scout troop stays lost until discovered days later by Ranger Rick.
  - Request forwarded to Google after scouts are returned safely home.

Disruption-tolerant access to content

- What Scout Master Chuck didn't know is that Junior Scout Billy has maps of the area in the browser cache of his Sony PlayStation Personal.
- With disruption tolerant access to content, Chuck's request could have been satisfied by Billy's PSP.
- Disruption-tolerant scenario
  - Chuck's request for new maps is received by local PDAs, iPods, etc. Each checks to see if request can be satisfied by cached content.
  - Billy's PSP determines it can satisfy the request, and replies with the cached map.
  - Chuck successfully leads troop out of the woods.

Challenges for content-based DTN

- Need distributed indexing, querying and retrieval.
  - Conventional distributed database models don't work for DTN.
- Indexing will need to include reachable caches.
- Data may be encrypted; source must be authenticated.
- Users should be told of data freshness, time to retrieve, and have control over how cache misses are handled.

Note: we understand that this is a large problem space, and don't expect to solve it completely.

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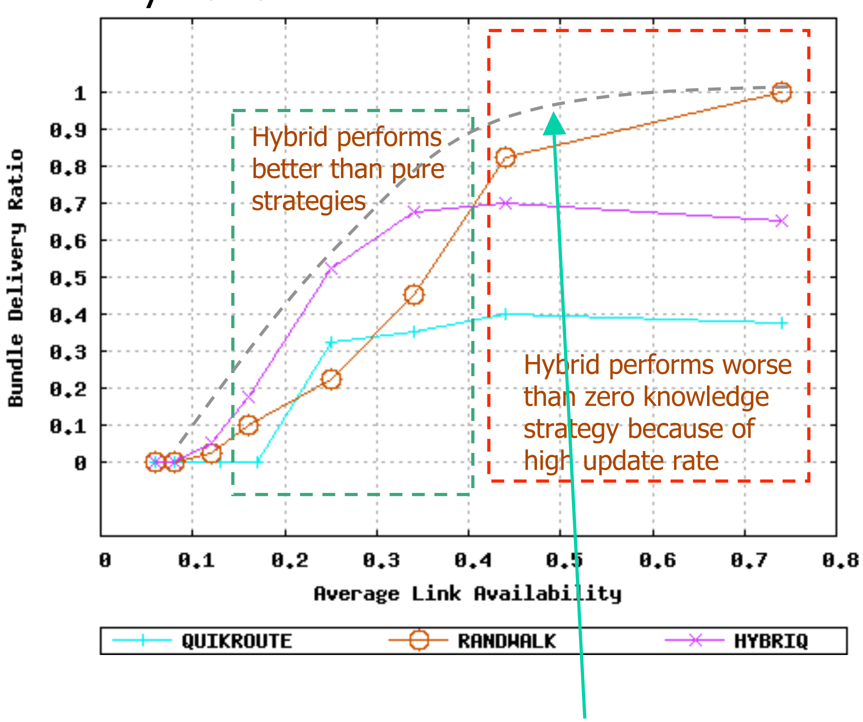
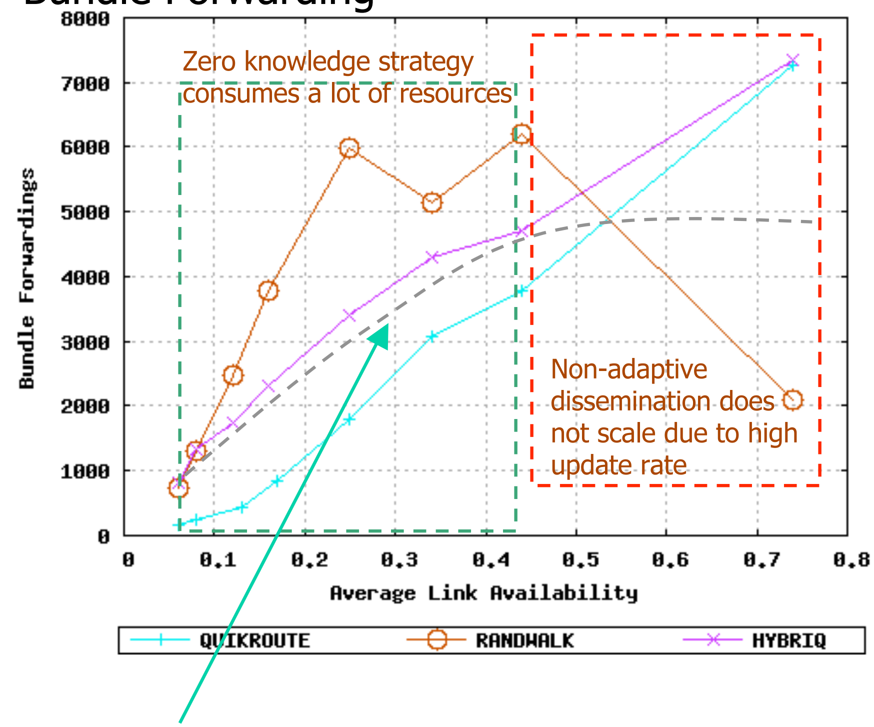
Adaptive routing and network state dissemination

Offered load: 40 bundles of 2800 bytes; Time:1200s*; Source-Destination path: 6-7 hops
In case of dissemination-based strategies, LS updates are sent every 30s

Delivery Ratio



Bundle Forwarding



Adaptive network state dissemination will help us track these curves

*Time allowed is not sufficient to deliver all bundles in this 5-x-4 grid DTN scenario

Adaptive routing and network state dissemination

- Adaptive hybrid routing strategies
  - Make use of routing information when available.
  - Explore locally when path is unknown or highly uncertain.
  - Dynamic choice of strategies based on policy.

- Adaptive state dissemination service shared by routing strategies
  - Exchange subset of topology information with neighbors.
    - Algorithm is not quite link state or distance vector.
    - Uses succinct space-time representation of topology.
  - Control rate, scope, and content of updates.
  - Tradeoff control overhead versus opportunistic data transfer.
  - Service can be used to distribute policy/naming/content metadata.

Policy-based resource utilization

- Declare and control resource use in DTN nodes
  - Link formation/use based on costs and delivery requirements.
  - Storage management.
  - Choice of security services.

- Use a declarative language to express and process policies
  - Node primitives controlled by policy are explicitly declared.
  - Deductive database rules check for policy consistency and conformance of usage to policy.
  - Constraint solver searches for communication opportunities that are authorized by policy

- Protocol for policy dissemination and consistent use in a DTN.

Summary

- Engineering of DTN Reference Implementation (DTN2)
  - Feature development
  - Testing
  - Documentation
  - Plug-in interfaces and plug-ins.

- Research
  - Intentional naming and late binding
  - Content-based networking
  - Routing and adaptive dissemination

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