An Overview of Disruption Tolerant Networking Technologies

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Outline

- Motivation for Disruption Tolerant Networking
- What it is, how it works
- Types of DTNs
- Current Research Areas
- Work from USC

Internet Background

Internet's Success (TCP/IP protocol suite)

- Consensus based communication protocols
  - Routing (IP)
  - Reliable data transfer (TCP)

- Unwritten Assumptions
  - Source and Destination are continuously connected (forming bi-directional end-to-end paths)
  - Short roundtrip times (small delays)
  - Relatively symmetrical data rates
  - Low bit error rates
  - Maximum Transmission Unit of 1500 bytes (Ethernet World)

- Packet switching

Extend it Everywhere!

Evolving Networks

Interplanetary Internet(IPN)

Highly Mobile Tactical Network

Habitat Monitoring - ZebraNet

Sensor Networks - Autonomous node control

Properties of Evolving Nets

Evolving networks do not follow the Internet's underlying assumptions.

In fact they exhibit the exact opposite characteristics

- Intermittent Connectivity
- No contemporaneous path
- Variable and/or long delays
- Asymmetric data rates
- High bit errors

The Result

TCP/IP fails!!

New research has emerged…

Delay/Disruption Tolerant Networking

DTN Overview of Work

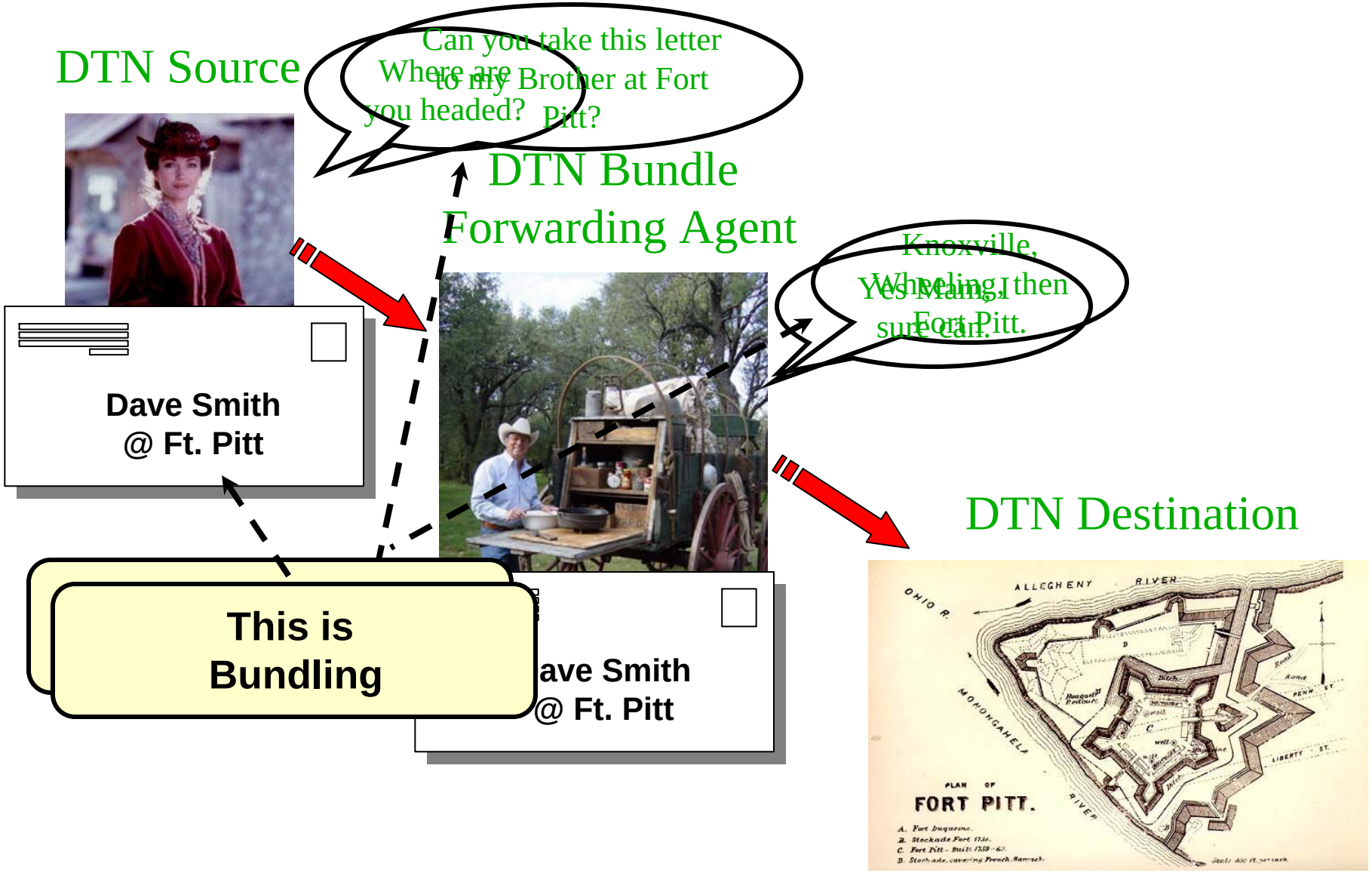
www.dtnrg.org

What is DTN?

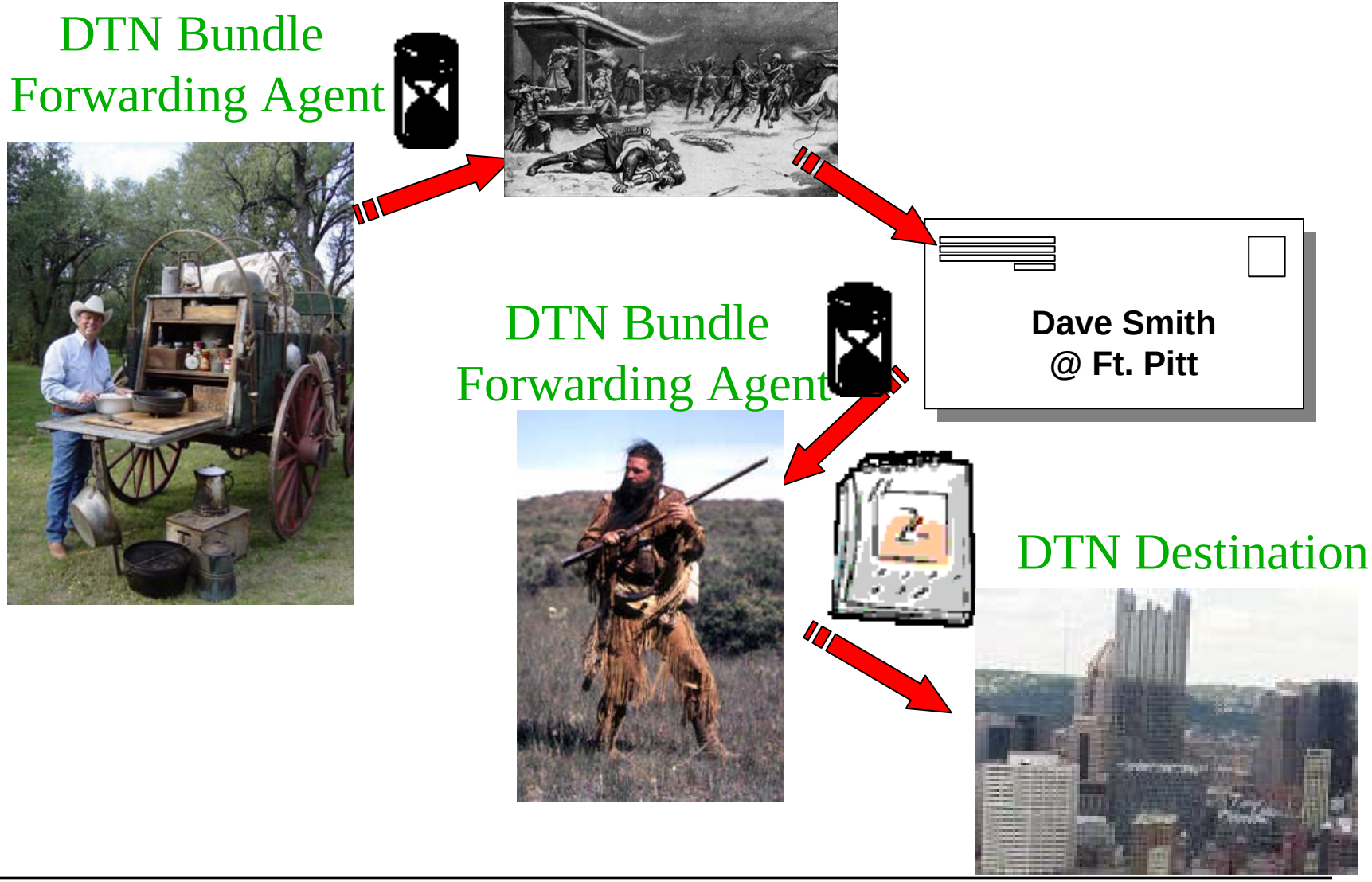
DTN is a network of regional networks

- Networks that violate one or more of the underlying TCP/IP assumptions
- Really it's just an overlay
- Accommodates long delays between regions and even within regions
- Underlying physical/link layers maybe very diverse
  - Radio Frequency (RF)
  - Ultra-wideband (UWB)
  - Sonar or ultrasonic
- Store and Forward Network (Message Switching)

DTN in a nutshell

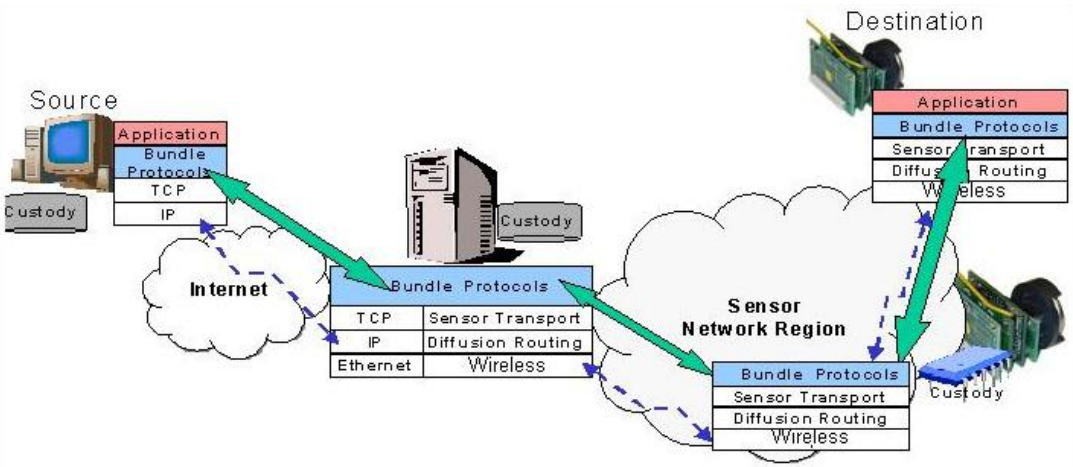


DTN in a nutshell

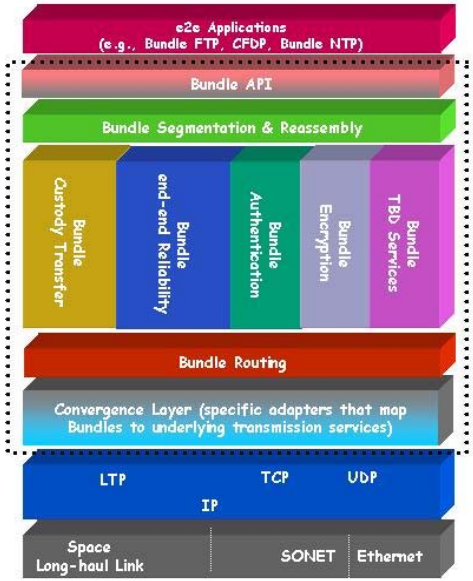


Overview of DTN Architecture

- Regions and DTN Gateways
- Name Tuples
  - Allow for late binding
  - Based on Uniform Resource Identifier (URI)
- Path Selection/ Routing decisions
- Bundling layer: aggregates messages
- Custody transfer
- Convergence Layers (TCP, UDP, LTP)
- Security



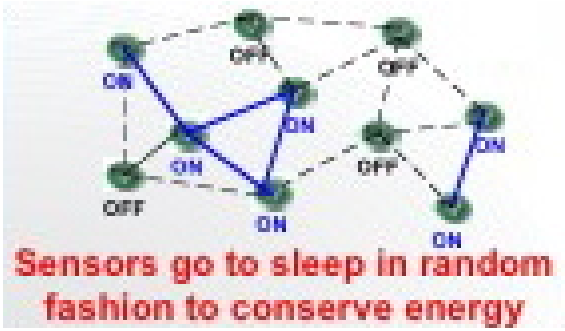
"Bundling"



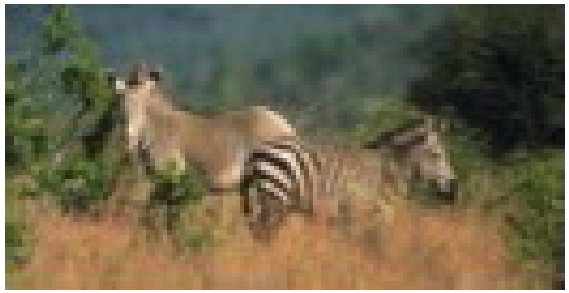
Types of DTN applications?

- Scheduled

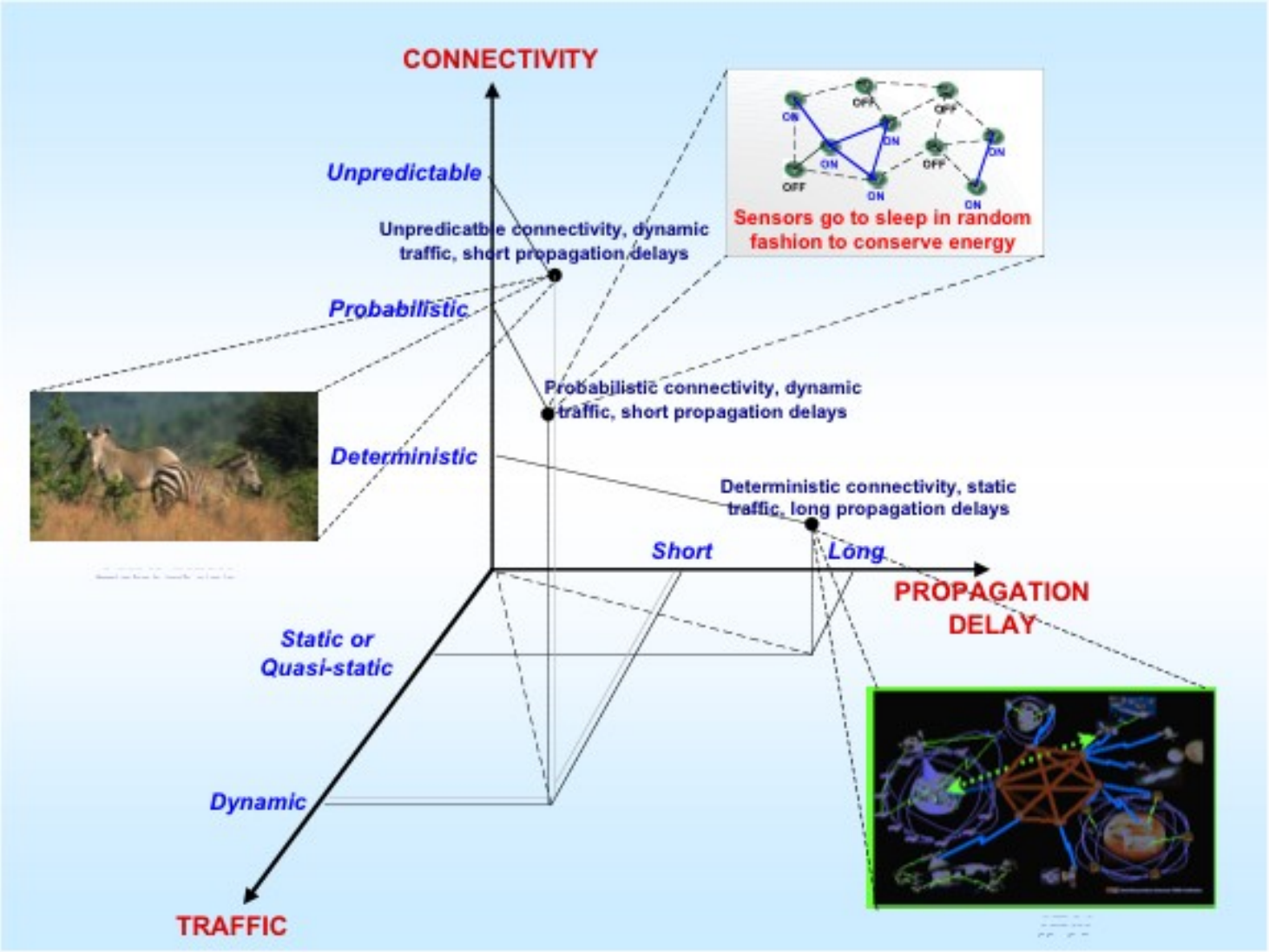
- Probabilistic



- Opportunistic



Problem Space Design



Research challenges

- Architecture
  - Naming, Bundles, Convergence layers
- Routing
  - Family of protocols, broadcast
- Congestion/Flow control
  - Family of algorithms
- Security
- Deployment
- Testbeds and Experiments

DTN Research Status

CATEGORY 1: BUILD-OUT OF CURRENT CAPABILITIES	CATEGORY 2: EXPANSION OF CORE DTN CAPABILITIES	CATEGORY 3: DTN BASIC RESEARCH AREAS
a. Security model b. Prioritized traffic c. Imposition of schedule/contact limits (data rate, volume, etc.) d. Custody transfer e. Reactive fragmentation f. Process persistence and reanimation Š integration with scheduling and power management capabilities	a. Network management statistics gathering and control mechanics b. Development of DTN proxies for – FTP, – SMTP, – Foreground and background web traffic (pull with low priority cache population) – Instant Messaging – Voicemail/push-to-talk radio – Network News – SNMP c. New convergence layer s and adapters – SMTP – Digital Fountain	a. Congestion avoidance and remediation. b. Software to characterize routes – Pure opportunistic – Histogram-based prediction – Bayes-net conditional prediction c. Routing protocols to express the full range of routing alternatives – Always-on – On-request – Scheduled – Predicted – Opportunistic d. Routing algorithms for optimal allocation of outbound traffic to a mixed set of contacts e. Integration of externally-developed routing and congestion management capabilities

Current Research

- Routing for sensor type networks
  - Spray-n-wait
  - Seek-n-focus
- Experimental testbed development
  - Emulab augmented with mobility models
- Congestion control
  - Three different algorithms

Routing in DTN's

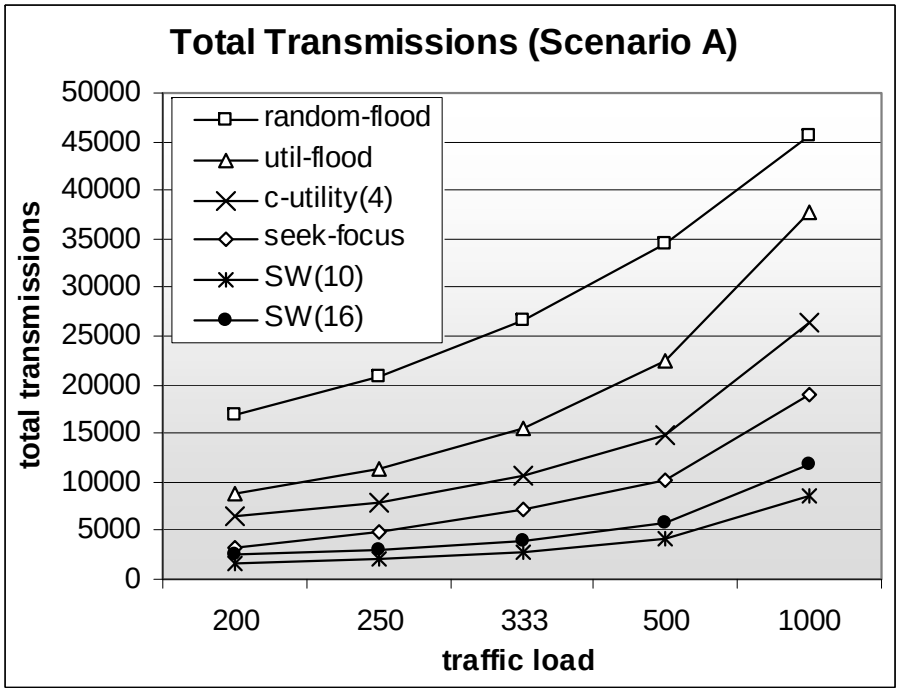
- Two ends of the spectrum
  - Flooding (minimum delay)
  - 1-Hop: (minimum transmissions)
- Based on utility functions
  - Time last seen
  - Storage capacity
  - Mobile capability
  - Power to live
- USC
  - Two different algorithms

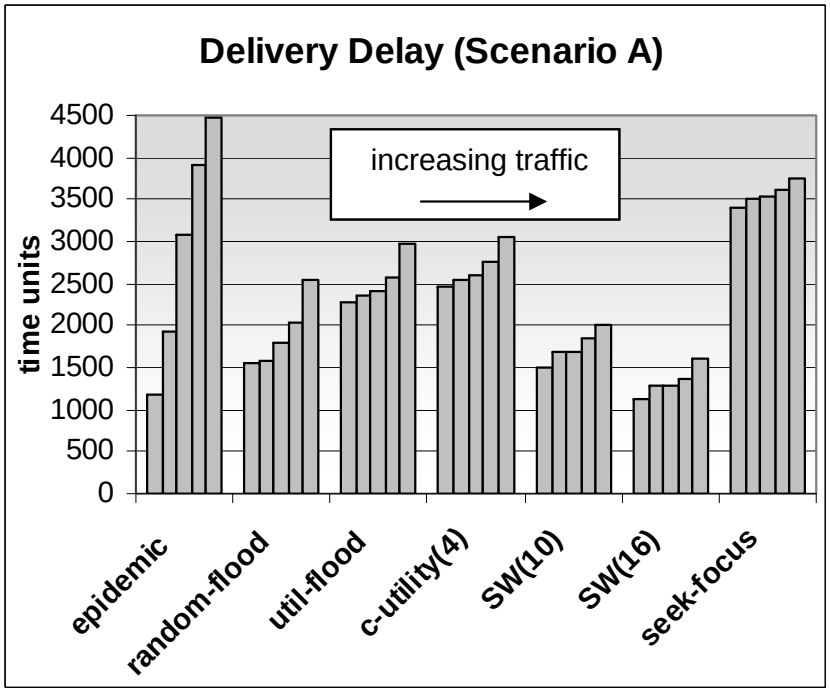
Routing in DTN's

- Seek-n-focus
  - Seek - Low utility, random
  - Focus - follow utility function
- Spray-n-wait
  - Spray L messages(copies)
  - Wait

Scenario A: Effect of Traffic Load

(500x500, M = 100 nodes, K = 10)





	Delay	Transmissions
Low traffic	same as epidemic 1.4-2.2x other schemes	>10x epidemic 3-4x constrained
High traffic	1.8-3.3x	same as above

Experimental Testbeds

What an Emulab like system provides:

- Dynamic link conditions for delay, bandwidth, and even link availability
- Ability to run *Bundling Protocol* on top of a topology and over different topologies
- Ability to evaluate routing protocols across the variety of networks discussed earlier
- A common facility for other researchers to conduct experiments
  - Avoids everyone having their own "version/vision" of what constitutes a DTN

Conclusion

- Motivation for Disruption Tolerant Networking
- How they work
- Types of DTNs
- Current Research Areas
- Work from USC

www.dtnrg.org

Special thanks to Will Ivancic
NASA Glenn Research Center for the *western themed* DTN example slides

Thank You!

Questions?