Introduction to Delay/Disruption Tolerant Networking

Ioannis Komnios (ikomnios@ee.duth.gr)

Part II
Space communications

- Planet movement impacts Line-of-Sight
- Solar storms cause disruptions

Alternative paths exist, but are not being exploited

*DTN is the solution!*
Envisioned scenario
Protocol stack
DTN in Space so far

- DINET / EPOXI
- UK-DMC / SARATOGA
- DTN in Space
- METERON
- ISS
Space Internetworking Center

- Located in Xanthi, Greece
- Involved in several ESA & EU projects
- Key mechanisms developed:
  - Delay-Tolerant Payload Conditioning (DTPC)
  - Bundle Streaming Service (BSS)
  - Contact Graph Routing (CGR) enhancements

http://www.spice-center.org
Space Data Routers

http://www.spacedatarouters.eu
DTN routing protocols differ in two main aspects:

- **Amount of available information**
  - No knowledge
  - Partial knowledge
  - Full knowledge

- **Number of copies to create per bundle**
  - Multi-copy
  - Single-copy

- **Protocols**
  - Epidemic
  - Spray-and-Wait
  - PRoPHET
  - MaxProp
Floating content

- An opportunistic content sharing system designed to store and distribute local spatio-temporal information in uncoordinated fashion

- The system relies solely on the mobile nodes passing through the area of interest

- Information dissemination is geographically limited

- The lifetime and spreading of information depends on interested nodes being available

- Content can only be added, but not deleted.

http://www.floating-content.net
DTN implementations

- **IBR-DTN**: Embedded systems and mobile nodes
- **DTN2**: Reference implementation for Linux
- **ION**: Space communications
- **μDTN**: Sensor networks
IBR-DTN

- Modular implementation of Bundle Protocol in C++
- Initially embedded devices and later extended for Android devices
- Suitable for OpenWRT routers
- Developed by the Technical University of Braunschweig in 2008 and still gets updates!
- 3 Android apps exist

https://www.ibr.cs.tu-bs.de/projects/ibr-dtn/
https://trac.ibr.cs.tu-bs.de/project-cm-2012-ibrdtn/wiki
© IBR-DTN daemon
DTN2

- DTN2 is the reference implementation developed by IRTF DTNRG in C++
- Suitable for Unix systems
- Supports several convergence layers and routing protocols
- No updates since 2012

https://sites.google.com/site/dtnresgroup/home/code/dtn2documentation
ION-DTN

- Focus on space DTN communications
- Developed by NASA’s Jet Propulsion Laboratory in C
- Supports:
  - Contact Graph Routing
  - Bundle Streaming Service
  - Delay-Tolerant Payload Conditioning
- Latest version 3.4.1: **constantly updated**

https://sourceforge.net/projects/ion-dtn/
µDTN

- DTN implementation for Contiki OS
- Suitable for low-power wireless sensor nodes
- Wireless communication via IEEE 802.15.4
- Developed by the Technical University of Braunschweig in 2012
- Interoperability with IBR-DTN on Linux

https://www.ibr.cs.tu-bs.de/trac/mudtn/
Other implementations

- Bytewalla/Hurrywalla
- DTNLite
- ContikiDTN
- 6LoWDTN
- CoAP over BP
ONE simulator

- Developed by Aalto University

- The Opportunistic Network Environment simulator supports:
  - Different movement models
  - Various DTN routing algorithms
  - Visualisation of mobility and message passing in real time in its GUI
  - Import of mobility data from real-world traces or other mobility generators
  - A variety of reports and general statistics

https://akeranen.github.io/the-one/
ONE simulator
BP for NS2 and NS3

- DTN for NS2 focusing on energy aspects from Democritus University of Thrace

- DTN for NS2 and NS3 available from Aalto University

http://www.spice-center.org/dtn-agent/
https://www.netlab.tkk.fi/tutkimus/dtn/ns/
DTN in mobile devices

- DTN2 for Maemo
- Android IBR-DTN
- Bytewalla based on DTN2
- DT-Talkie on Symbian
Existing DTN apps

- Web
- Mail
- Facebook
- Twitter
- DT-Talkie
Existing DTN apps

✧ Web
✧ Mail
✧ Facebook
✧ Twitter
✧ DT-Talkie

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Existing DTN apps

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- DT-Talkie

IBR-DTN apps

- ShareBox
- Whisper
- Talkie

Liberouter apps

*Liberouter is an opportunistic communication network that enables communications directly between nearby mobile users without the need for Internet connectivity*

*GuerrillaTags*
- Messaging application

*GuerrillaPics*
- Photo sharing application

*PeopleFinder*
- Disaster recovery application

*Here and Now*
- Experience sharing application

https://www.liberouter.mobi
DTN-bone

- A worldwide collection of nodes running DTN bundle agents and applications
- Suitable for remote management and control of nodes, interoperability, application deployment and testing
- Managed by the DTNRG
- Includes ION, DTN2 and IBR-DTN nodes

https://sites.google.com/site/dtnresgroup/home/dtn-bone
SPICE testbed

✧ A DTN testbed for satellite and space communications

✧ Deployed at the Space Internetworking Center

✧ Equipped with specialised hardware components for the accurate emulation of space links and ground stations
Integration with ICN

Two research projects funded by the European Commission

UMOBILE focuses on assisting users in getting access to the content they want or content that may be of shared interest to their trust circles.

RIFE addresses the major societal challenge of providing affordable Internet access to those who cannot afford it.

http://www.umobile-project.eu
https://rife-project.eu
What we learned so far

- DTN in Space
- Which DTN implementations can I download?
- What about simulation tools?
- Existing DTN apps
Coming up

✧ Hands-on experience with IBR-DTN!
Thank you for your attention!

Any questions?