Introduction to Delay/Disruption Tolerant Networking

Part II

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The Abdus Salam International Centre for Theoretical Physics

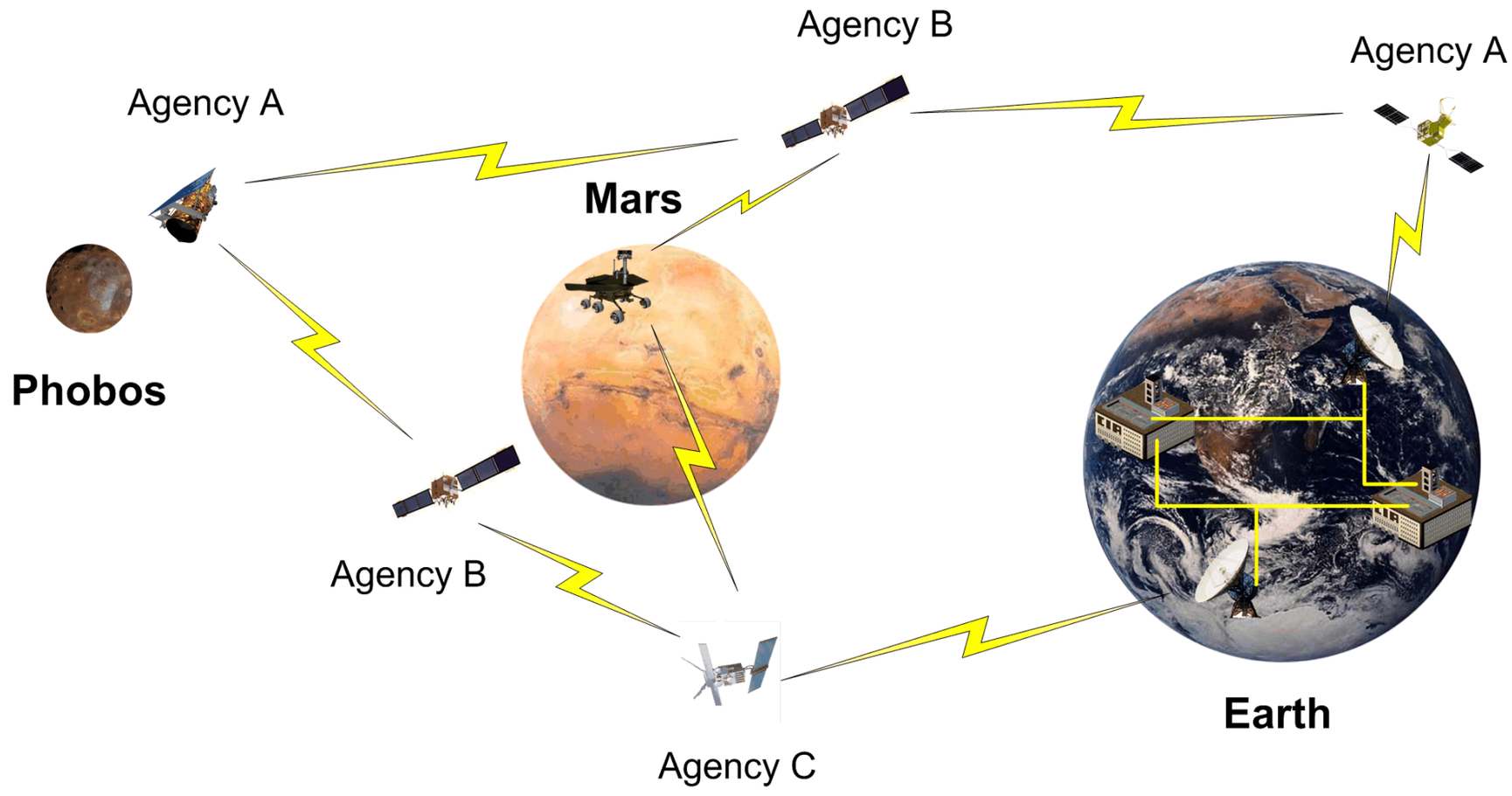
Space communications

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

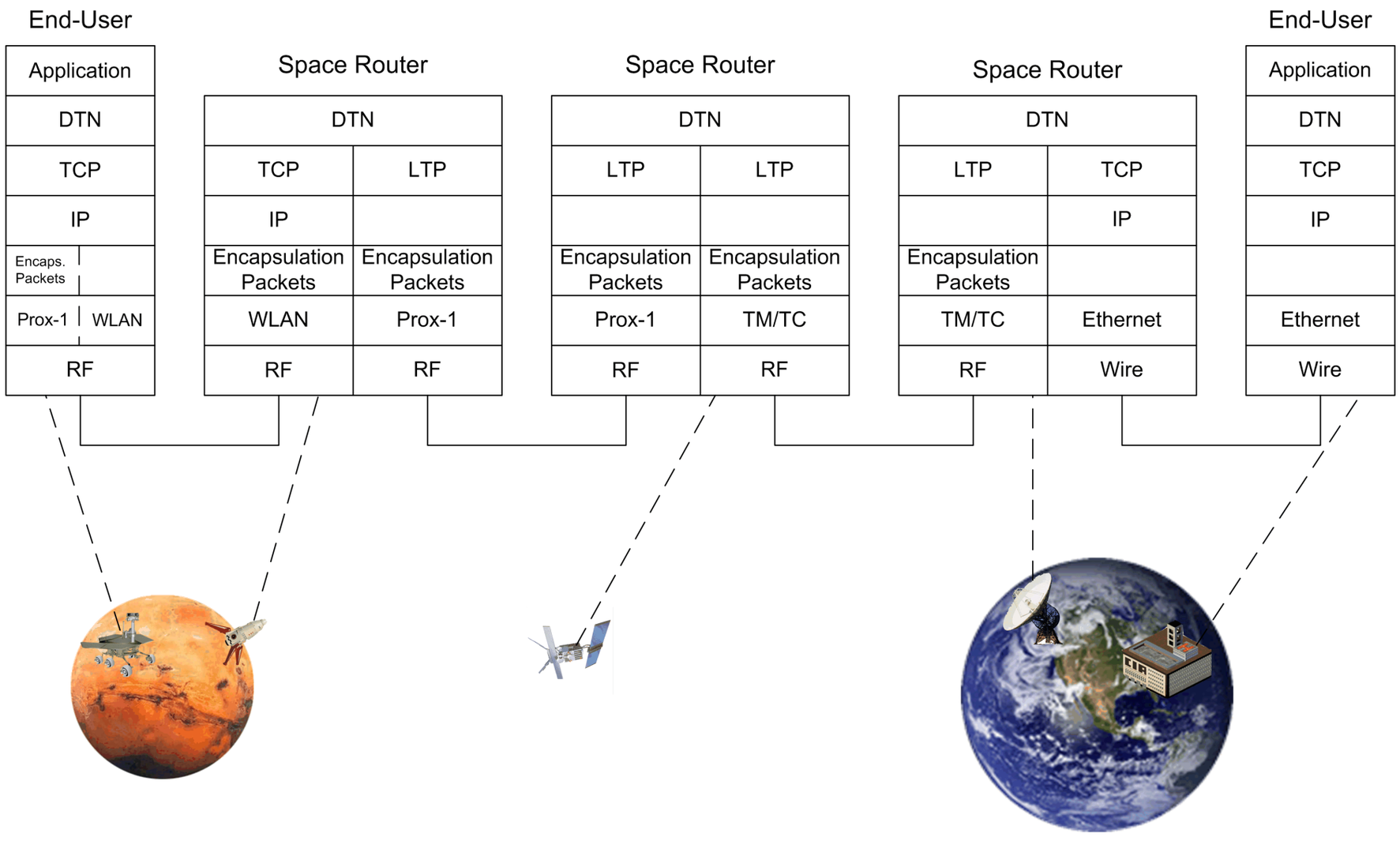
Alternative paths exist, but are not being exploited

DTN is the solution!

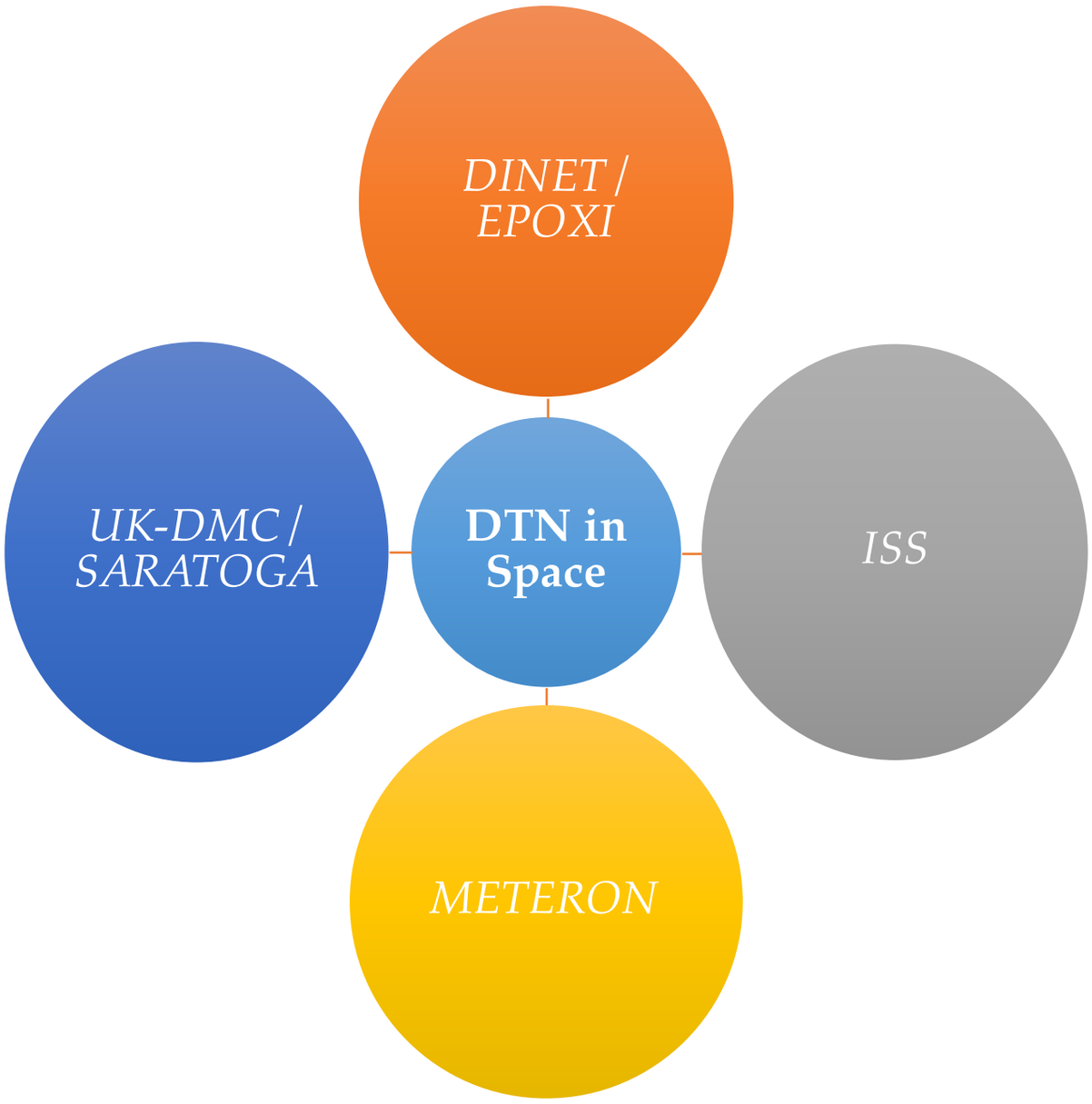
Envisioned scenario



Protocol stack



DTN in Space so far

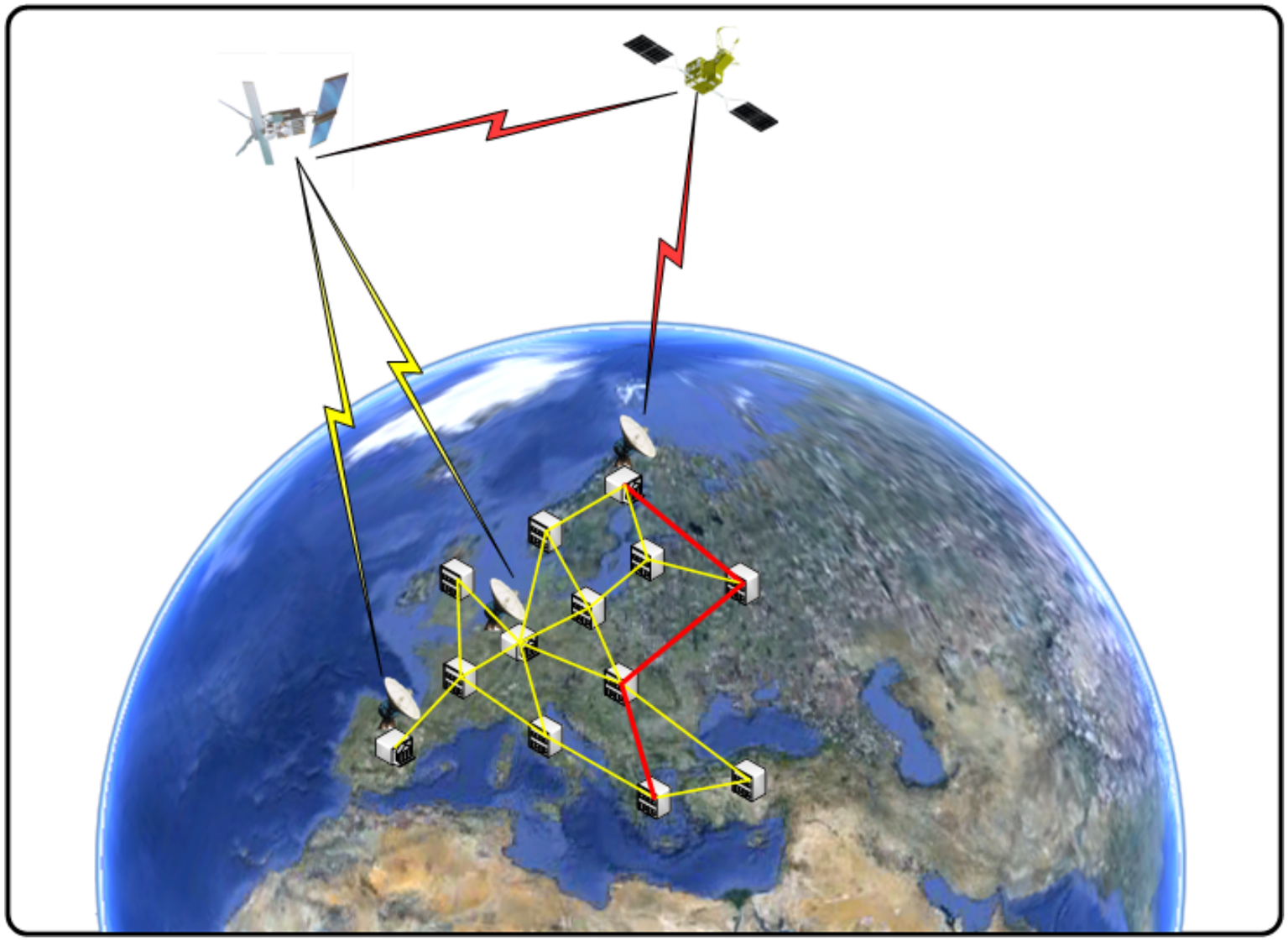


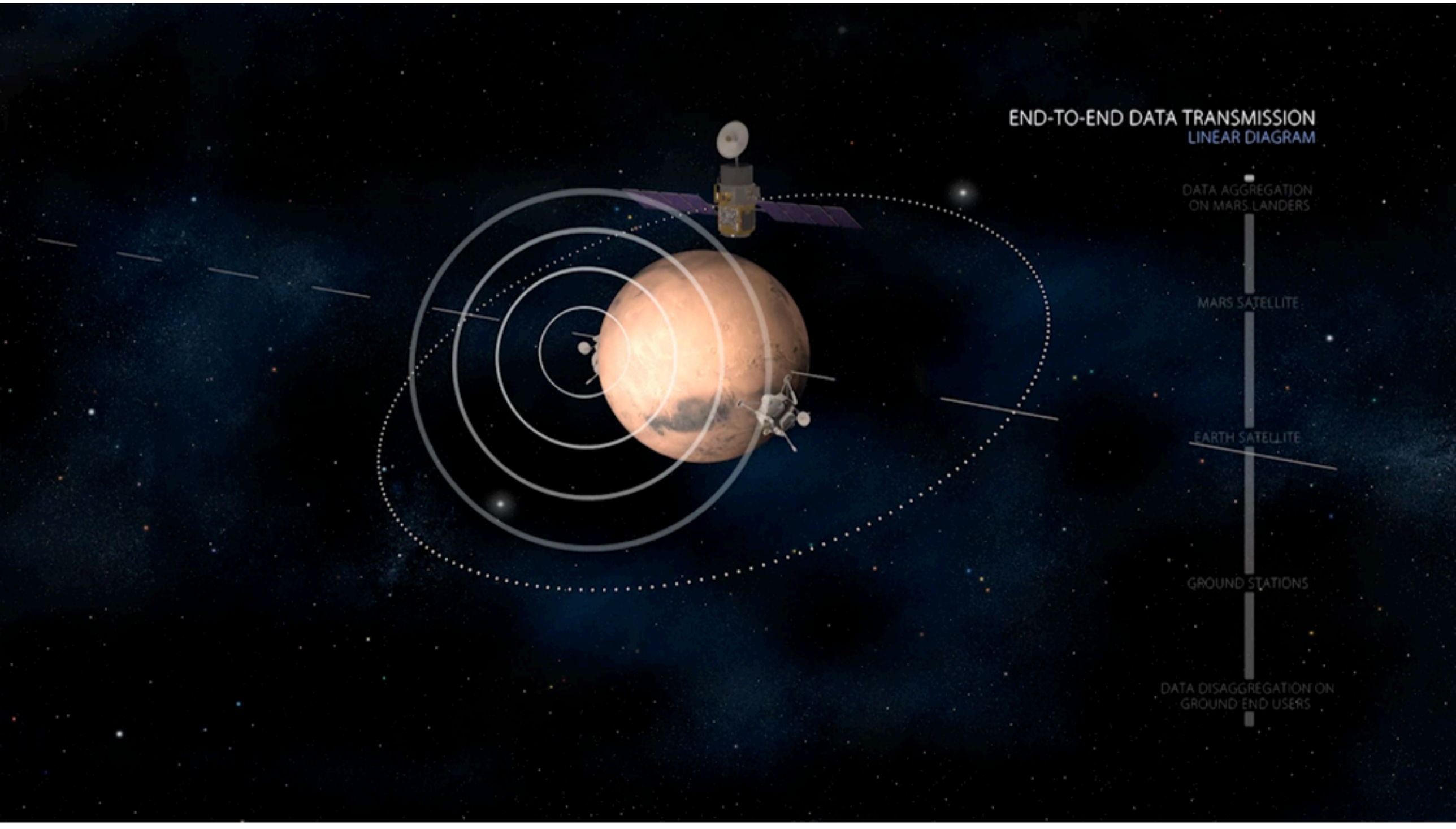
Space Internetworking Center

- 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

SPICE
SPACE INTERNETWORKING CENTER

Space Data Routers

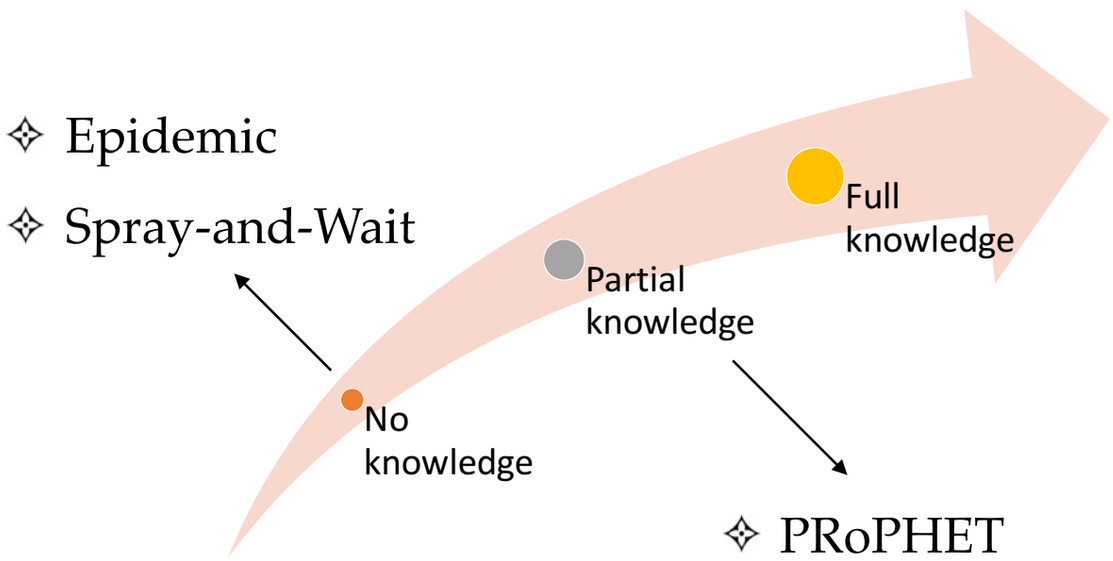



END-TO-END DATA TRANSMISSION
LINEAR DIAGRAM
DATA AGGREGATION ON MARS LANDERS
MARS SATELLITE
EARTH SATELLITE
GROUND STATIONS
DATA DISAGGREGATION ON GROUND END USERS

DTN routing so far

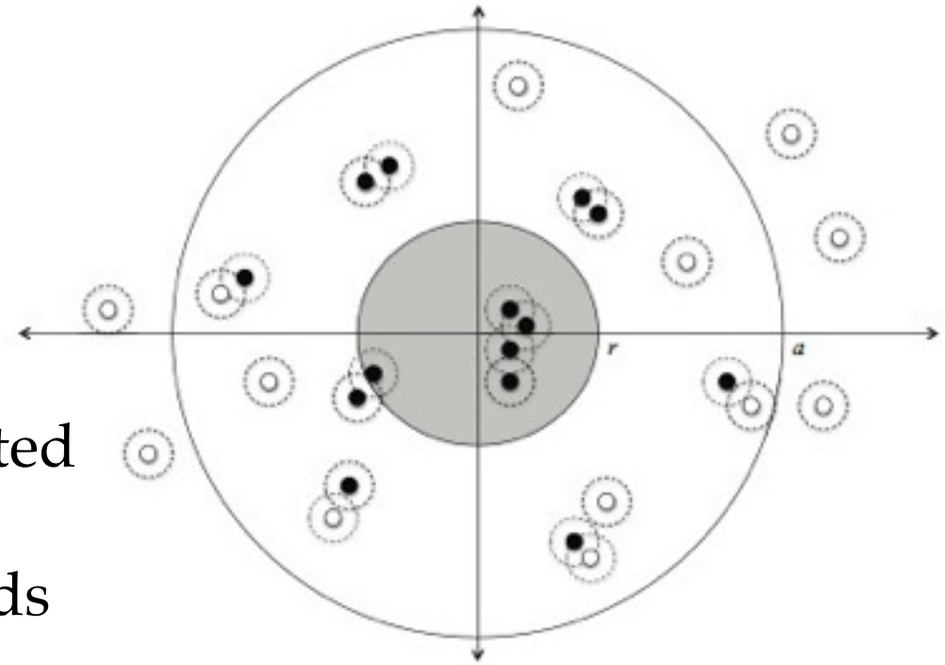
DTN routing protocols differ in two main aspects:

Amount of available information	Number of copies to create per bundle



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.



DTN implementations

IBR-DTN
- Embedded systems and mobile nodes

DTN2
- Reference implementation for Linux

ION
- Space communications

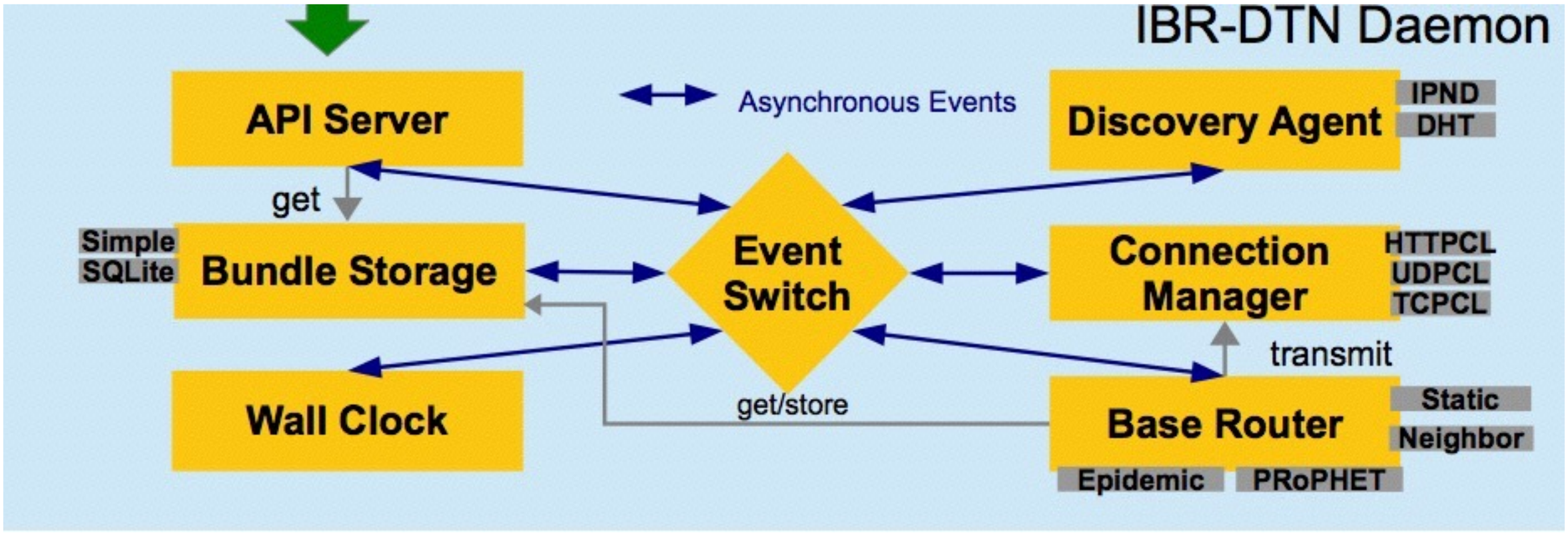
µDTN
- Sensor networks

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

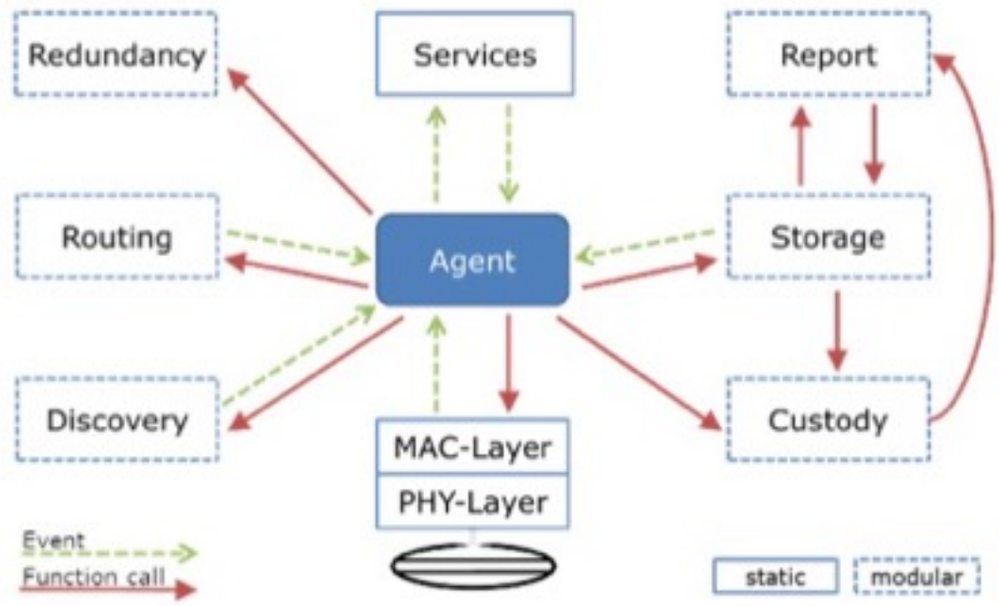
ION-DTN

- 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



Other implementations

Bytewalla / Hurrywalla

DTNLite

ContikiDTN

6LoWDTN

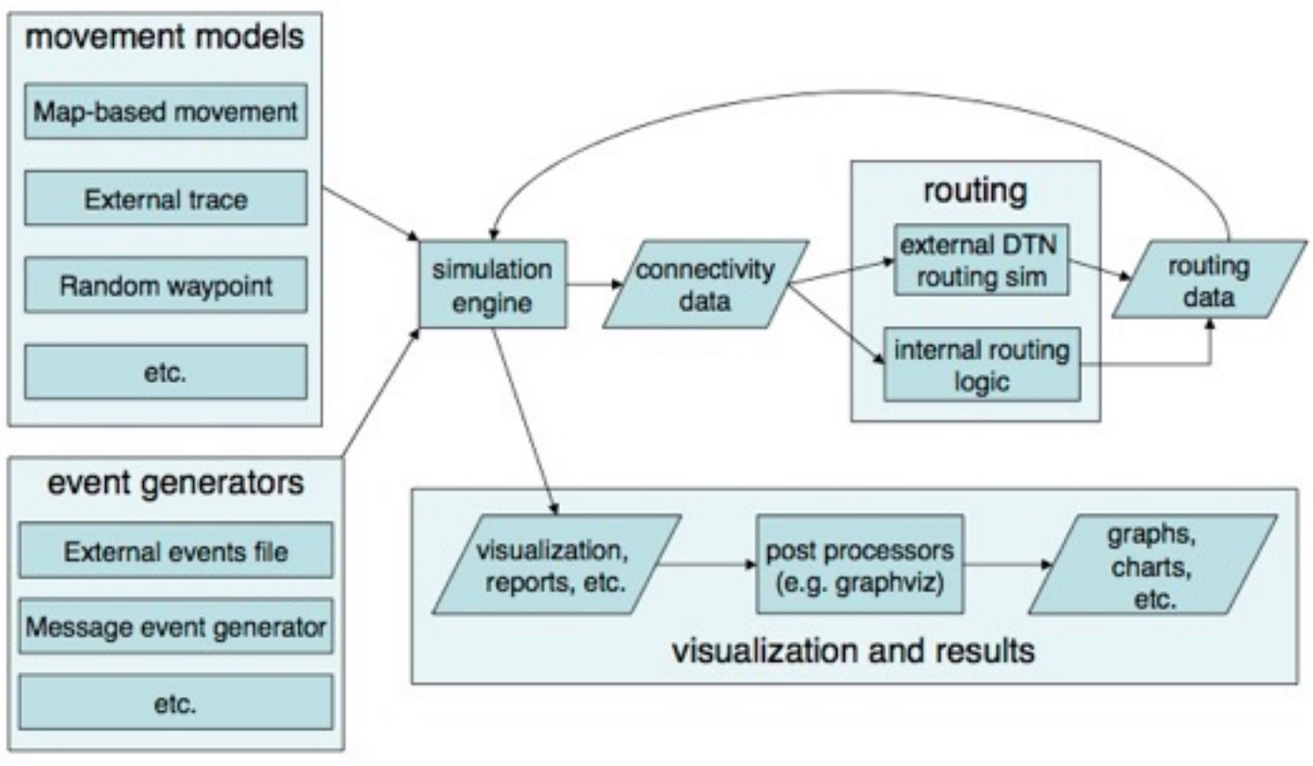
CoAP over BP

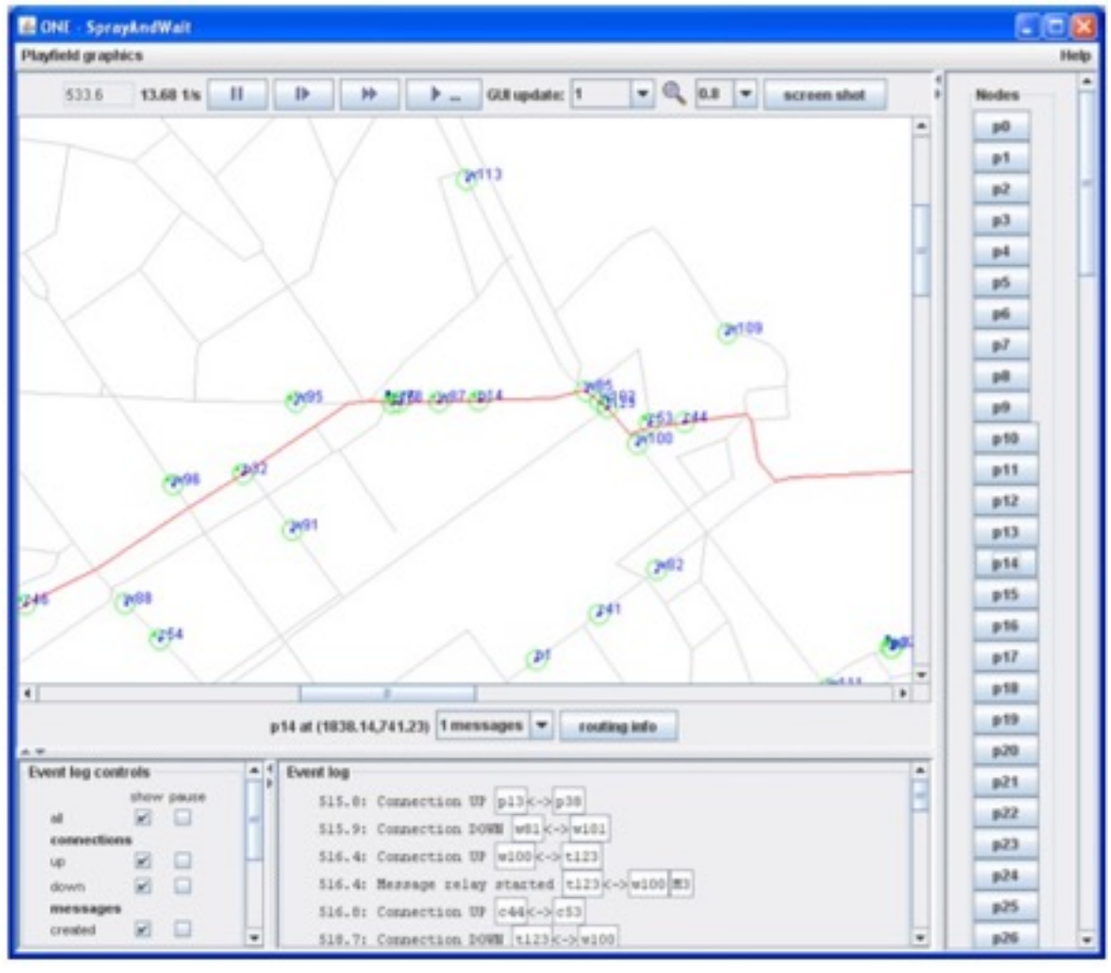
ONE simulator

- 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

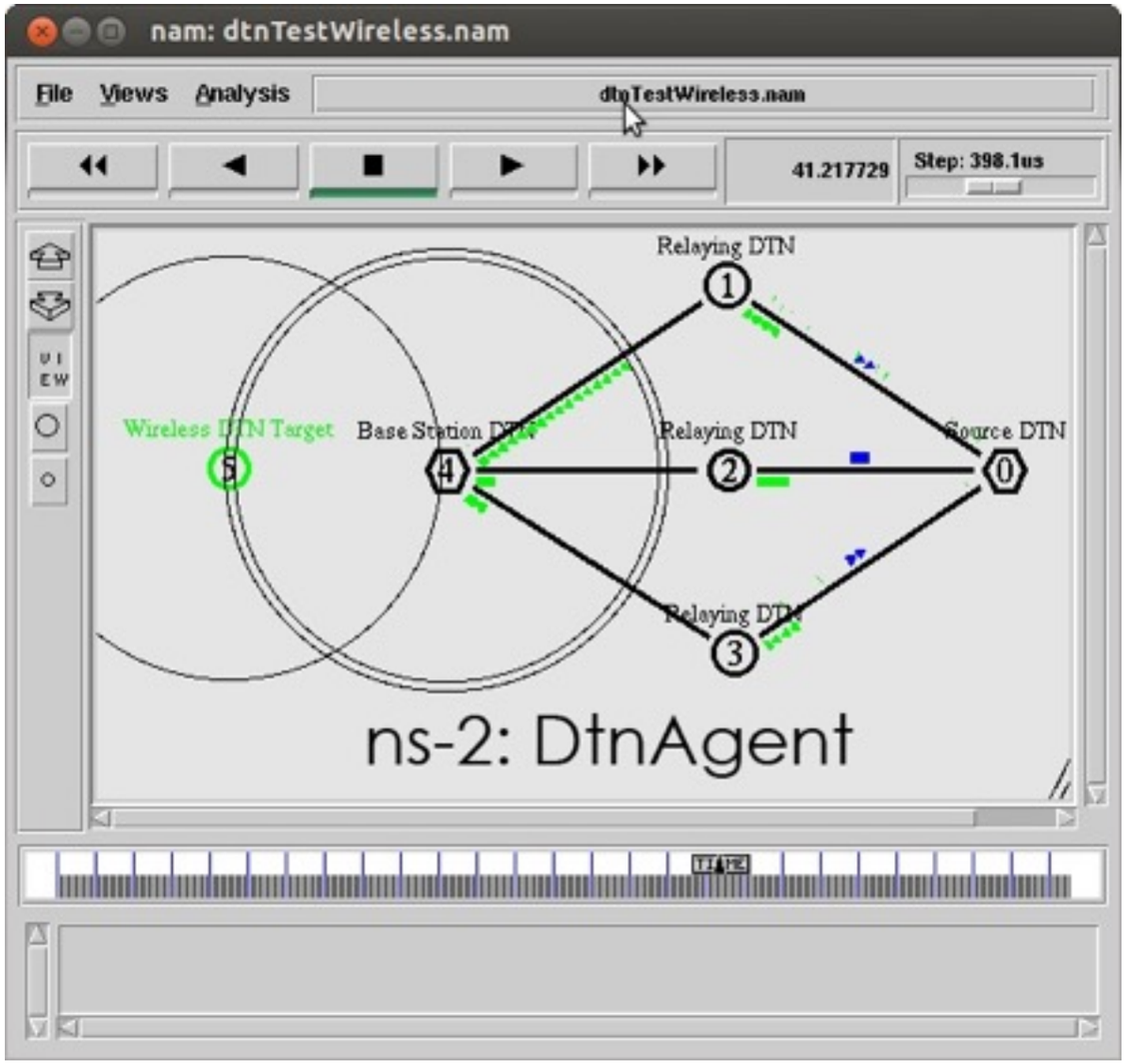




BP for NS2 and NS3

- 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

Ott, J. and D. Kutscher, "Bundling the Web: HTTP over DTN", WNEPT 2006 Workshop on Networking in Public Transport, August 2006
Anders Lindgren. 2011. Social networking in a disconnected network: fbDTN: facebook over DTN. In *Proceedings of the 6th ACM workshop on Challenged networks* (CHANTS '11). ACM, New York, NY, USA, 69-70. DOI=http://dx.doi.org/10.1145/2030652.2030674

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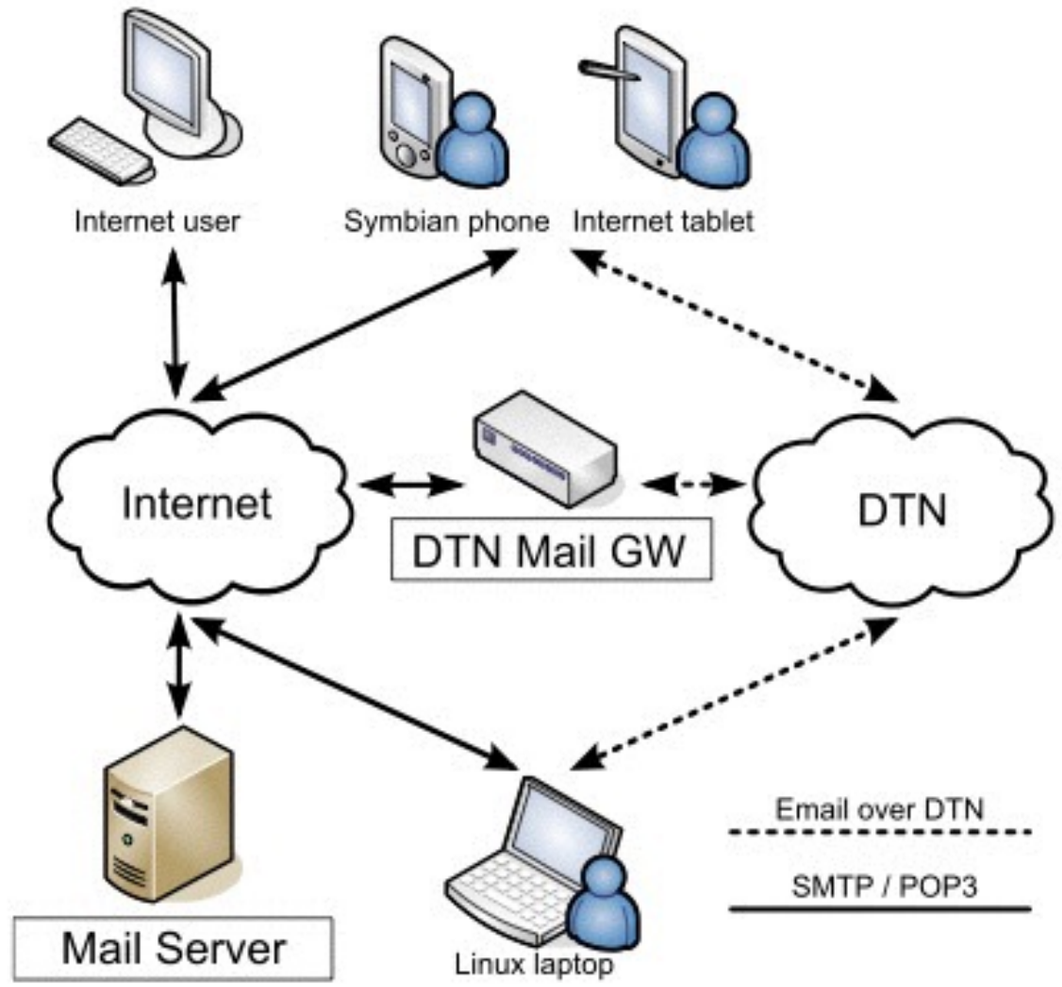

Tuomo Hyyryläinen, Teemu Kärkkäinen, Cheng Luo, Valdas Jaspertas, Jouni Karvo, and Jörg Ott. 2007. Opportunistic email distribution and access in challenged heterogeneous environments. In *Proceedings of the second ACM workshop on Challenged networks* (CHANTS '07). ACM, New York, NY, USA, 97-100. DOI=http://dx.doi.org/10.1145/1287791.1287811

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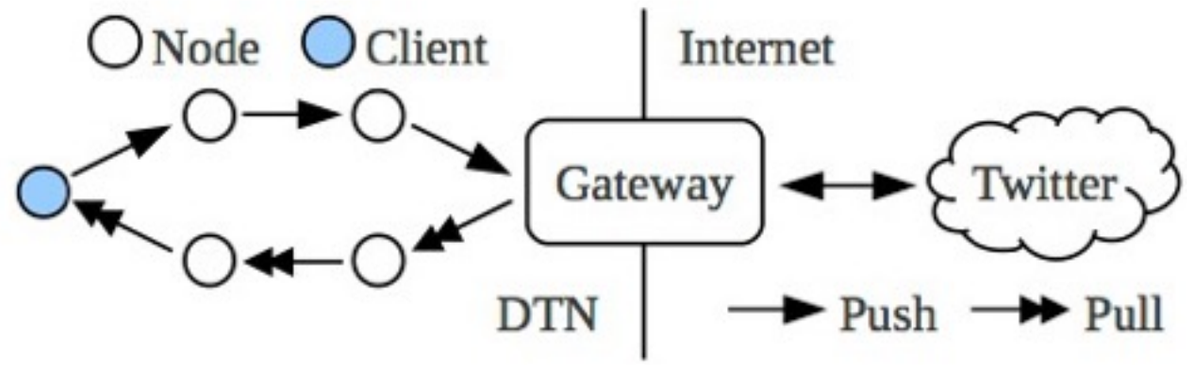

Kyle Zaragoza, Nathan Thai, and Terrance Christensen. 2011. An implementation for accessing twitter across challenged networks. In *Proceedings of the 6th ACM workshop on Challenged networks* (CHANTS '11). ACM, New York, NY, USA, 71-72. DOI=http://dx.doi.org/10.1145/2030652.2030675

Existing DTN apps

- Web
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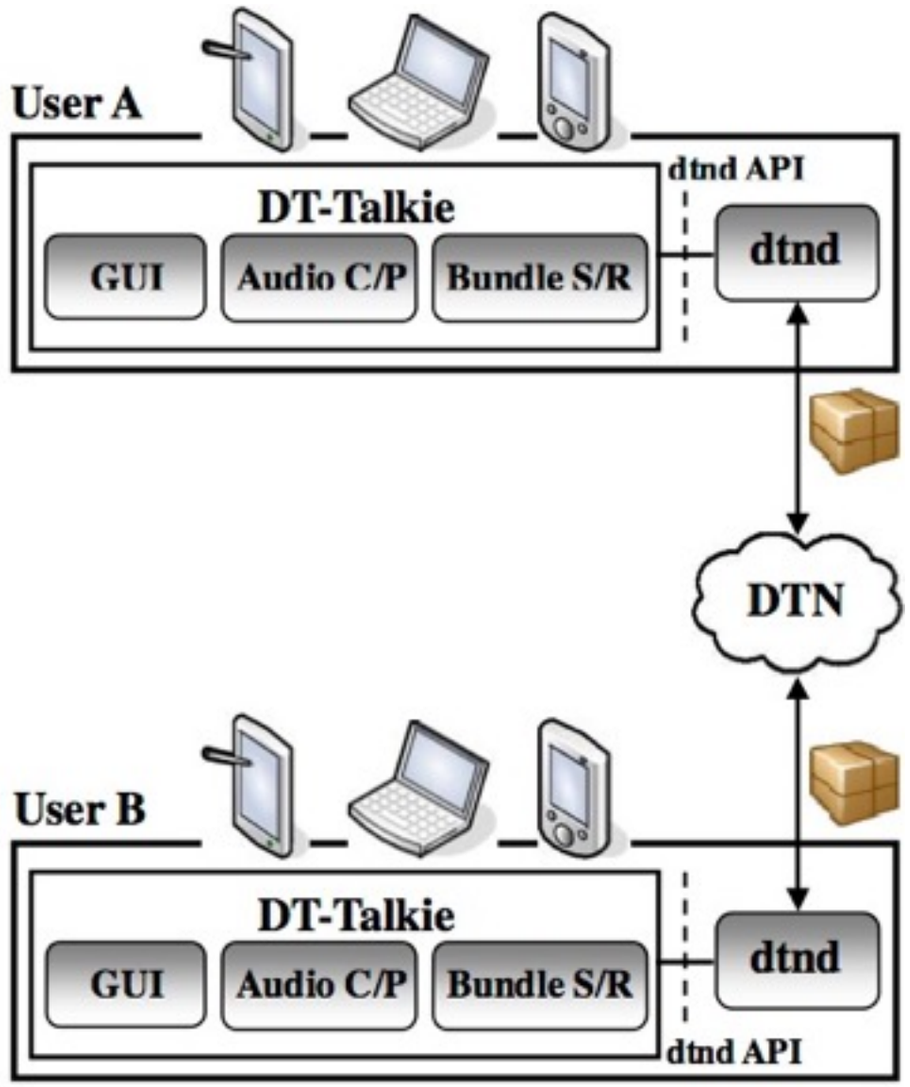
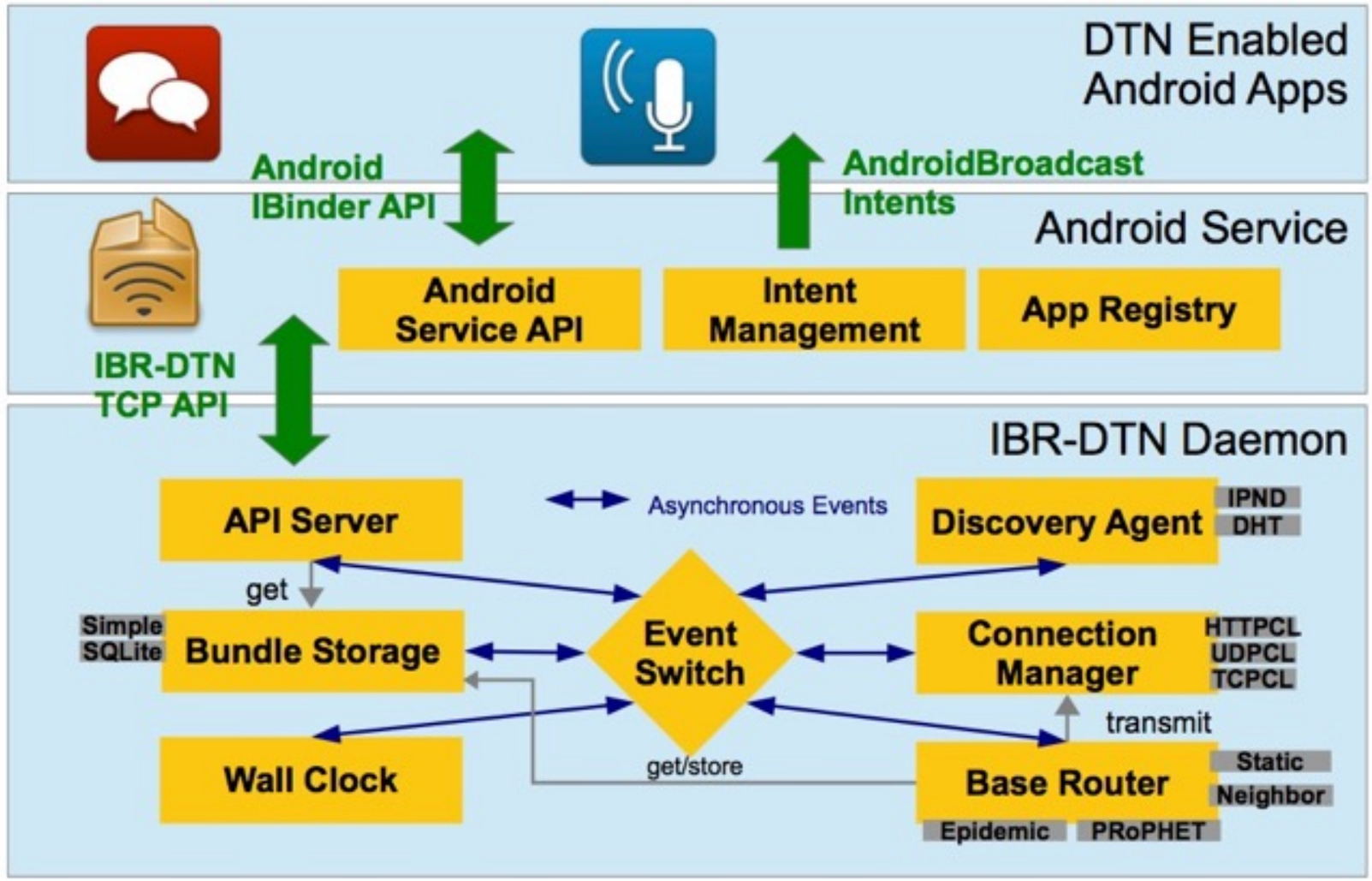
- **DT-Talkie**



M. T. Islam, "DT-Talkie: Interactive Voice Messaging for Heterogeneous Groups in Delay-Tolerant Networks," *Consumer Communications and Networking Conference, 2009. CCNC 2009. 6th IEEE*, Las Vegas, NV, 2009, pp. 1-2.
doi: 10.1109/CCNC.2009.4785007

IBR-DTN apps

- ShareBox
- Whisper
- Talkie



Johannes Morgenroth, Sebastian Schildt, and Lars Wolf. 2012. A bundle protocol implementation for android devices.
In *Proceedings of the 18th annual international conference on Mobile computing and networking* (Mobicom '12). ACM, New York, NY, USA, 443-446.
DOI=http://dx.doi.org/10.1145/2348543.2348606

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

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

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

I. Komnios, I. Alexiadis, N. Bezirgiannidis, S. Diamantopoulos, S.-A. Lenas, G. Papastergiou and V. Tsaoussidis, "SPICE Testbed: A DTN Testbed for Satellite and Space Communications", 9th International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities (TRIDENTCOM 2014), Guangzhou, China, May 5-7, 2014.

Integration with ICN

- Two research project 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?