Wireless Networks
Lecture 21: Wireless and the Internet

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Outline

- The Internet 102
- Wireless and the Internet
- Mobility: Mobile IP
- TCP and wireless
- Disconnected operation
- Disruption tolerant networks

Disconnected Operation

- Mobility means that some needs will occasionally disconnected from the network
  - » Seconds ... Minutes … Hours .. Days
  - » Mostly an issue for clients
- This can confuse systems and applications that assume a wired/stationary model
  - » Clients cannot access servers, e.g., mail, calendar applications, …
  - » Distributed file systems
  - » Systems for back up or systems management
- Must adapt the applications and systems to make them “disconnection aware”

Two Examples

- E-mail: users must be able to “work on” e-mail offline and operations are performed when the mobile client is redirected
  - » Compose, read and delete e-mail
  - » Possibly others: manage folders, etc.
- Calendars and tasks are similar: operations performed offline must be executed later
  - » Adding or removing appointment and tasks, …
- Must sometimes resolve conflicts when multiple clients are used offline
  - » E.g., mail is deleted on one client and moved to another folder on another – delete or keep?
  - » Tend to be minor – ask user for help if needed

More Complex Case: File System

- A distributed file system can be accessed from many computers
  - » Files tend to be cached in the computers
- Creates opportunities for inconsistencies
  - » E.g., a file is modified on two different computers – how do you merge the changes? Who is responsible?
- The consistency model depends on the file system
  - » Stronger consistency requires that the system can keep track of all copies and remove/lock them if needed
- Disconnected operation makes the consistency problem harder!
  - » Some file copies my be inaccessible for long periods!

Mobility is Common Today

- Many applications are designed to work on mobile clients so they deal properly with disconnections
  - » Most clients server applications can work offline with at least partial functionality
- Does not work for interactive applications
  - » Games, etc.
- Disconnection can still be very inconvenient
  - » Need state that is not cached on your client device
  - » Things like back ups cannot be performed
  - » Unpredictable delays in communication

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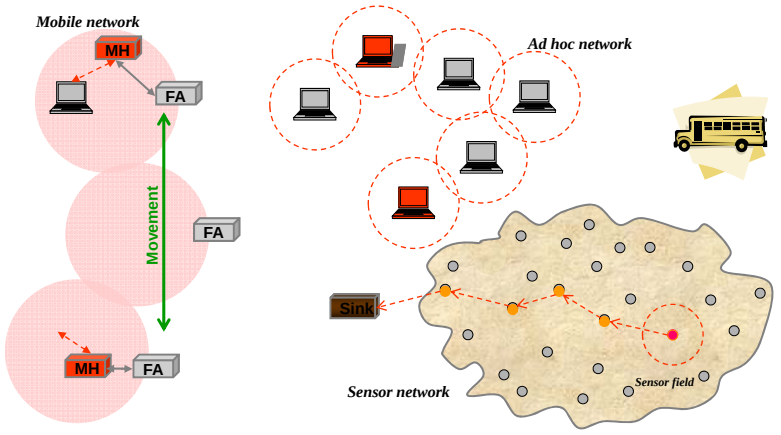
Based on slides by Kevin Fall

Challenges Networks

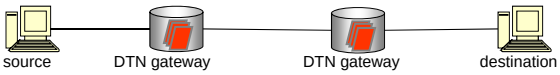
- Violate one or more of Internet's assumptions
  - » Very long delay path, frequent disconnections, …
  - » Have their own specialized protocol stacks
  - » Have naming semantics for their particular application domain
  - » Not be well served by the current end-to-end TCP/IP
- Examples
  - » Terrestrial mobile networks
  - » Some ad-hoc networks
  - » Sensor/actuator networks
- Goals for "delay tolerant" networks
  - » Achieve interoperability between very diverse types networks
  - » Sometimes also called disruption tolerant

Background



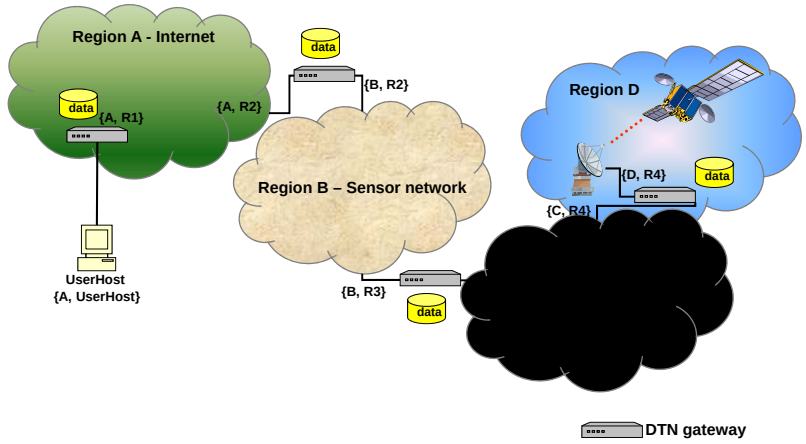
High-level Architecture

- **Characteristics:**
  - » **Operate as an overlay above the existing transport layers**
  - » **Based on an abstraction of message switching**
    - – **Bundle**
    - – **Bundle forwarder (DTN gateway)**
    - – **Store-and-forward gateway function between different networks**



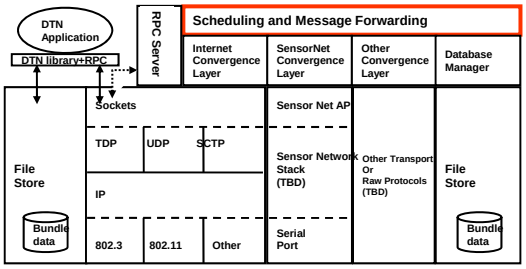
- **Constituent of DTN architecture**
  - » **Region: internally homogenous, i.e. same network stack, addressing, …**
  - » **DTN gateway: Interconnection point between region boundaries**
  - » **Name Tuple: {Region name, Entity name}**

Example DTN



DTN Gateway

- The gateway is a router for bundles (messages)
  - » Must do routing and packet forwarding
- Cannot assume an end-to-end routing path exist
  - » Route is a sequence of Cascade of *time-dependent contacts (communication opportunity)* from source to destination
    - – Contact = {start_time, end_time, …}
  - » Gateway estimates a contact's predictability, selects message(s) to send and chooses the next-hop forwarders



Bundle Forwarding

- Forwarding a bundle involves a "custody transfer": next DTN gateway assume responsibility
  - » Requires hop-by-hop reliability: explicit acknowledgement of delivery of message from one DTN hop to next
  - » Also requires persistent storage of bundles
  - » Can have "non-persistent" forwarding
- Class of service (CoS)
  - » Priority-based resource allocation
  - » Postal Service model
    - – Non-interactive
    - – Coarse granularity and intuitive character : low, ordinary, high

Application Interface

- Application should not expect a timely response
  - » Destination not connected to the network at the same time
- Generally operate where a request/response turn-around time exceeds the expected longevity of the client and server processes
- Functions that must be supported
  - » Name tuple creation, manipulation, and registration
  - » Class of service classifier
  - » Authentication information
- Continue operate in the face of reboots or network partitioning as much as possible

Discussion DTN

- DTNs cover a very wide variety of networks
  - » Hard to come up with a single efficient solution
- In practice, DTNs are often present at the edge of the network on
  - » Core of the network is the Internet
  - » This has been the focus of the research so far
- A lot of research has focused on using DTNs in areas without network infrastructure
  - » The DTN is a bus or train that “picks up” bundles a few times a day
  - » It is possible to schedule “transmission” based on the bus schedule

Conclusion

- DTN’s contribution
  - » Provide interoperable communications between a wide range of networks
  - » Advocate a change to the basic service model and system interface, mostly accustomed Internet-style applications
  - » Suggest model while keeping the current service model and existing TCP/IP based protocols constant
- DTN’s different choices in the architectural design
  - » Messages vs. packets
  - » Hop-by-hop reliability and security vs. end-to-end
  - » Name-based routing vs. address-based routing
  - » Partially-connected routing vs. fully-connected network graph