S-38.3455 Challenged Networks

Introduction

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Overview

- Seminar (5-10 ETCS points)
- Introduction (today)
- Mid-term presentations: initial review + feedback
- Seminar presentations, extended afternoon seminar
  - 30 – 45min  Presentation and discussion per topic
  - One opponent per topic
- Overview and assignments: today
- Dates and venue: according to course webpage
Motivation to DTN Scenarios

- Several large photographs about extreme environments (space, rural) and urban environments (commuting in subway, mall) were removed from this part to enable sharing in Web.
- Main purpose of this was to motivate the wide array of application scenarios.
Routing in Challenged Networks
Contacts

- In the Internet addressable entities are online all the time
  - Disruptions are treated as transient failures => time invariant cost

- In DTNs we expect communication to be possible only intermittently
  - Links have time varying delay and capacity => time varying cost

\[ \int c(t)dt = \text{Volume} \]
Contact Types

- Persistent
  - DSL

- On-demand
  - Dial-up connection

- Scheduled
  - Deep-space applications

- Opportunistic
  - Ad-hoc connections

- Predicted
  - Based on past observations or other information
Space Paths vs. Space-Time Paths
Challenges of Routing in DTNs

- The scope of applicability of the DTN architecture is very large
  - In deep-space missions topology and contacts are known ahead of time
  - In rural networks topology is known, but connectivity outages unpredictable
  - In mobile ad-hoc networks all contacts are opportunistic

- A single, grand routing algorithm might not be realistic
  - Need to understand the different classes of DTNs
    - Informal classification by Borrel, Ammar and Zegura [1]
    - Formal classification by Ramanathan, Baus and Krishnan [2]
  - Need to understand the different classes of routing approaches
    - Classification by Zhang [3]


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Informal Network Classification

- **Space-Path Network (SPN)**
  - Space-paths exist between all the nodes
  - The typical “MANET” network

- **Unassisted DTN (U-DTN)**
  - Space-Time paths exist between all the nodes
  - The typical DTN network

- **Assistance-needed DTN (A-DTN)**
  - No paths exist between some nodes
  - Separated network islands, needs “assistance” to connect
Informal Network Classification

SPN = Space-Path Network
U-DTN = Unassisted DTN
A-DTN = Assistance-needed DTN
Classification of Routing Approaches

- Classification based on knowledge of schedule
  - Deterministic: Future topology and contacts well known in advance
    - e.g., deep-space networks
  - Stochastic: Future topology and contacts not known in advance
    - e.g., (sparse) mobile ad-hoc networks

- Formal classifications exist as well
  - Borrel, Ammar and Zegura
    - Routing centered network classification based on evolving graphs
  - Ramanathan, Baus and Krishnan
    - Classification based on three attributes: 1) end-to-end path required, 2) single copy (no replication), 3) unavailable schedule.
Routing Approaches

Deterministic
- Space time routing
- Tree approach
- Modified SPF

Stochastic
- Epidemic / Random Spray
- Prediction-based
- Model-based
- Control movement
- Coding-based
Numerous Challenges

- Getting a message from A to B
  - With sufficiently high probability to make it worthwhile (70% is not enough)
  - Within an acceptable delay (a week may be way too long)

- Distributing/sharing contents among groups/all nodes
  - Achieving effective and efficient replication
  - Not bothering non-interested nodes (too much)

- Limiting network resource utilization
  - Buffer overflows lead to messages being dropped
  - Full buffers may overwhelm transmission capacity during contacts
  - Mobile devices are subject to battery and processing constraints

- Utilizing infrastructure in DTNs
Seminar Organization
Requirements

- **Contents**
  - Summarize and interpret the contents of at least 3 papers
    - Initial contents provided; further search welcome
  - Synthesize / interpret: go beyond the plain summary

- **Seminar presentation**
  - 30 minutes
  - Slides (digital: PS, PDF, or PPT)
    - Will be provided on the course web page after the seminar
  - Preparation meeting by individual appointment to discuss contents

- **Written summary: 5–8 pages**
  - Double column style of IEEE journal / conference proceedings
  - Should be sent one week prior to the seminar (14.2.)
    - Also to the opponent
    - Will be published on the course web page
Background Reading

- A Delay-Tolerant Network Architecture for Challenged Internets
- Routing in intermittently connected mobile ad hoc networks and delay tolerant networks: overview and challenges
- Efficient Routing in Intermittently Connected Mobile Networks: The Single-copy Case
- Efficient Routing in Intermittently Connected Mobile Networks: The Multi-copy Case
- DTN: An Architectural Retrospective
- RFC 4838 - Delay-Tolerant Networking Architecture
Finding Topical Material

- Several conferences and workshops cover related topics
  - Infocom, Sigcomm, MobiSys, IMC, Co-next, Mobicomm, WWW, etc...

- Journals
  - often for more mature results, but e.g. ACM CCR contains timely material

- Search also other relevant keywords than just DTN
  - opportunistic networking, challenged networks, mobile social networks, disrupted communications, vehicular communications

- Support your story with timely data
  - market reports, newspaper articles, etc.
Topics (1)

1. Resource Management
   - Max-Contribution: On Optimal Resource Allocation in Delay Tolerant Networks
   - Retiring Replicants: Congestion Control for Intermittently-Connected Networks
   - Congestion Aware Forwarding in Delay Tolerant and Social Opportunistic Networks

2. Mobility
   - Estimating and Sampling Graphs with Multidimensional Random Walks
   - Measuring serendipity: connecting people, locations and interests in a mobile 3G network
   - Habit: Leveraging Human Mobility and Social Network for Efficient Content Dissemination in DTN

3. Wireless Offloading
   - Mobile Data Offloading: How Much Can WiFi Deliver?
   - Opportunistic Web Access via WLAN Hotspots
   - Cellular Traffic Offloading through Opportunistic Communications: A Case Study
Topics (2)

1. Vehicular Communications and DTN
   - SPRING: A Social-based Privacy-preserving Packet Forwarding Protocol for Vehicular Delay Tolerant Networks
   - Performance Comparison of 3G and Metro-Scale WiFi for Vehicular Network
   - Maximizing the Contact Opportunity for Vehicular Internet Access

2. Social Aspects (I)
   - MobiCent: a Credit-Based Incentive System for Disruption Tolerant Network
   - Know Thy Neighbor: Towards Optimal Mapping of Contacts to Social Graphs for DTN Routing
   - Routing in Socially Selfish Delay Tolerant Networks

3. Social Aspects (II)
   - Listen to Me if You can: Tracking User Experience of Mobile Network on Social Media
   - Exploiting Locality of Interest in Online Social Networks
   - Social similarity as a driver for selfish, cooperative and altruistic behavior
# Topic Assignment

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