TakNet: A Rural Community Wireless Mesh Networking

Apinun Tunpan, Nisarat Tansakul and Kanchana Kanchanasut

Internet Education and Research Laboratory,
Asian Institute of Technology
Thailand

Presented by Kanchana Kanchanasut
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Outline

- DUMBONET background : disaster emergency communication research @ intERLab
- TakNet 1 : A rural community wireless mesh network
- TakNet 2 : A rural school wireless mesh network with an educational video-on-demand system

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Disaster and communication infrastructure

Flood can disrupt electricity supply and destroy internet data centers

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Characteristics of Mobile Ad hoc Networks (MANET)

PEER-TO-PEER
SELF-CONFIGURING & SELF-HEALING
ADAPTIVE TO TOPOLOGY CHANGES
MULTI-HOP, MULTI-PATH ROUTING
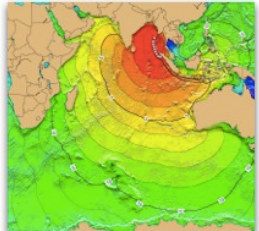MULTIMEDIA CAPABILITIES

Indian Ocean Tsunami of 2004

Image Source: NOAA

Disaster and communication infrastructure

A collapsed bridge can cut down fiber optics -- cutting communication to the whole region

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Commodity Devices

2006:
Large Notebooks

2008: Netbooks, and Bluetooth-enabled mobile phones

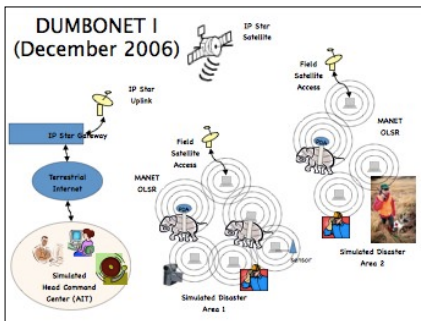2011: Tablets, Smartphones and Embedded systems

2013 - present: Mobile routers

DUMBONET I (2006)

A multimedia emergency communication network for the situations where there is severely disabled, or no communication infrastructure available.

Digital Ubiquitous Mobile Broadband OLSR Network
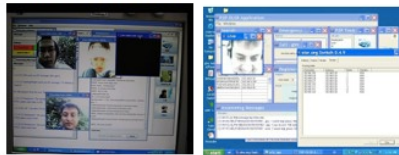a.k.a. "DUMBONET"

DUMBONET I (December 2006)

DUMBONET test in 2006

Features of DUMBONET I

- Interactive Video, Voice, and Instant Messaging
  - very important for situational awareness
- Peer-to-Peer Paradigm

Facial Recognition System (optional)

DUMBONET II (2008) : Connecting the vehicles

The project aims to demonstrate the use of mobile ad hoc networks in an emergency situation where fixed network infrastructure has been destroyed by natural disaster.

DUMBO2 is the second phase of the project where we assume that partial recovery of the fixed infrastructure has been successful. The focus of this phase is on how to automatically connect the mobile ad hoc networks to the fixed infrastructure in order to attach the networks set up for emergency scenario with the normal Internet.

Mobile nodes and routers are placed on small boats moving in the sea moving vehicles like motor bikes, tuk tuk and cars on the shore forming Vehicle-to-Vehicle (V2V) MANET. Fixed network access points placed within the proximity of the V2V network are the point of attachment to the normal Internet.

Multimedia communications among field workers using V2V network is the main target of this demonstration. The experiment will provide feedbacks for further enhancement for related network and application protocols for emergency situation.

Project Leaders:
- intERLab/AIT, Thailand
- Hipercom/INRIA and LOR/ Telecom SudParis, France
- WIDE Project, Japan

Tech Partners and Sponsors:
- NECTEC, Thailand
- UniNet, Thailand
- French Regional Coorperation, France

DUMBONET II : Connecting the vehicles

DUMBONET II : Connecting the vehicles


DUMBONET III (2010) : Challenged Networks

Khao-Yai (~"Grand Mountains) National Park, Thailand
- Trail in a dense tropical rainforest (~ 3 KM)
- Highly 'challenged' environment:
  - Trees and terrain disrupt our WiFi, CB, and GSM signals
  - Even GPS signal oftentimes cannot get through dense tree leaves

How to enable multimedia emergency communication in highly challenged and disruptive environments?


Coverage vs. Link Views

Coverage View

Connectivity (Link) View

····· is one DUMBONET hop (wireless)
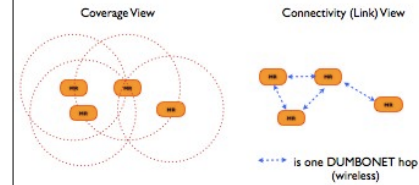
Maximum distance between any two farthest routers should not exceed 4 wireless hops

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DUMBONET IV (2013): Mobile Routers (MR)

- Approximately 100 - 150 meters of coverage radius.
- Shorter distance means a more stable and reliable link
- Built-in battery allows ~ 4 hours operation.
- We have replaced the factory firmware and specially customized the configuration parameters for emergency network operations
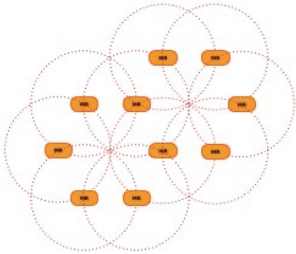

Example of Sparse Topology :

The sparse topology offers a reasonably wider or farer coverage in a specific direction. But if the nodes spread too far, the network might break into several segments

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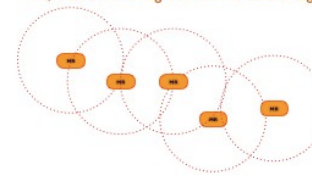
Example of Dense Topology :
Better robustness

How to connect the clients :
Put the clients in the covered area and connect to the nearest DUMBONET MR as normal Wi-Fi clients
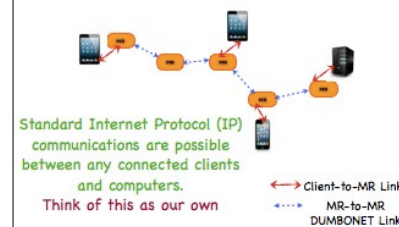
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4 simple steps to operate DUMBONET

1. Install the mobile routers in their designated places
2. Connect each router to a power supply or install a fully charged battery
3. Switch the routers to "ON" and wait
4. When the indicator lights start to blink, it's done: The DUMBONET emergency network is formed.

The Link View :

Standard Internet Protocol (IP) communications are possible between any connected clients and computers.
Think of this as our own

←→ Client-to-MR Link

·····→ MR-to-MR DUMBONET Link

Internet Gateway (IG) in DUMBONET

One DUMBONET node can be specially configured to connect to the public Internet (e.g. via Ethernet cable or 3G/4G cellular).
Add the IG node and then every client can access the public

For best results the IG node should be placed near to the center of the emergency network (i.e. to minimize hop count)

Public Internet

→ Public Internet
→ Client-to-MR Link
┄┄► MR-to-MR DUMBONET Link

Motivations

+ IT IS IMPORTANT TO HAVE EMERGENCY NETWORKS READY WHEN A DISASTER STRIKES !!

+ PEOPLE SHOULD KNOW KNOW HOW TO USE THE EMERGENCY NETWORKS, PREFERABLY THROUGH OTHER DAILY ACTIVITIES
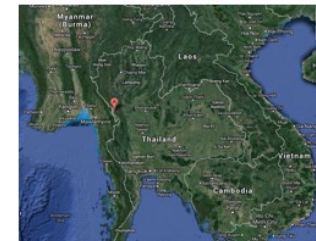
+ HENCE:

· Rural community disaster preparedness

· ICT literacy in rural areas

· DUMBONET mobile routers can be adapted to serve these purposes.

TakNet 1 (2013)

A rural community wireless mesh network

Testbed Location : Thai Samakhi Village, Mae Sot District, Tak Province, THAILAND

Mobile Routers in TakNet1

• Very low-cost (~ US$ 60 – 70)
• Wi-Fi 802.11n 2.4GHz Max150Mbps
• 16 GB USB flash storage for community applications and video files
• Low-powered, max 5W < US$ 0.70 per month
• Optional battery, for 4 – 5 hours of operations
• Flashed with OpenWRT Linux firmware and configured with OLSR
• Selectable options on community application services
    • voice over IP
    • video on demand
    • social networking in community wireless mesh network

Network was planned, installed, and tested by volunteers


TakNet1 Deployment Strategy

• Deployed by volunteers in March 2013

• Educational VoD service was introduced to the villagers

• A shared Internet Gateway node was added in May 2013

• Students and village people have been our enthusiastic users.

• Currently villagers are planning to share the cost of the shared Internet gateway

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Quick and easy installation

A custom-made range extender

Easy to use esp. on tablets

VoIP | The CWMN
Video on Demand | For curious minds

Lessons Learned from TakNet 1

- Rural people, especially the youths, are more enthusiastic about technology and Internet.

- The number of ADSL ports available to the villagers are limited. Some households cannot have their ADSL yet. Cost of ADSL is still relatively high, when compared to villagers' incomes.

- Although 3G is available, 3G is volume-limited and much more expensive than ADSL.

A piece of contemporary art endorsed by Steve Song
Networking on a pole
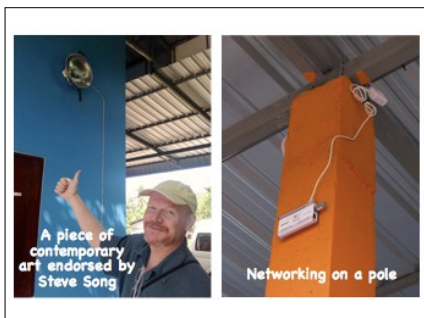
TakNet 2 (2014)

A rural school wireless mesh network with an educational video–on–demand system

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Networking problems in rural schools

- Several hundreds students share a relatively slow internet gateway — many rural schools have < 10Mbps links

- Although some rural schools start to have fibre Internet connectivity provided by UNINET, the lack of quality EDU contents still plagues most schools.

  - UNINET Fibre Internet and backbone could still easily be saturated, if hundreds of students simultaneously access high-bandwidth video contents.
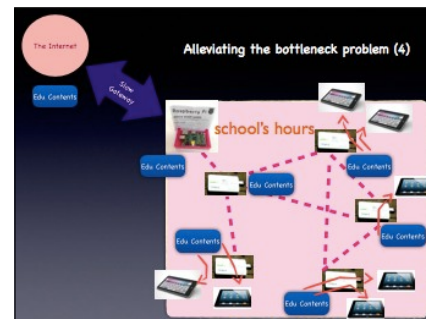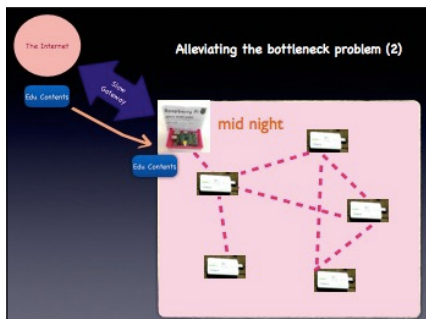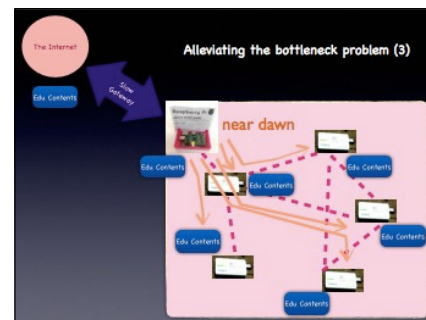

TakNet 2 : "Fiber to Mesh" concept
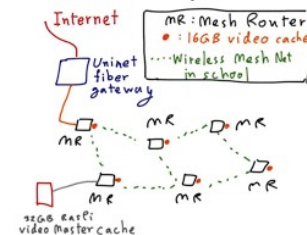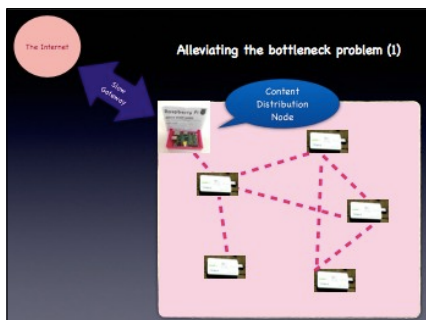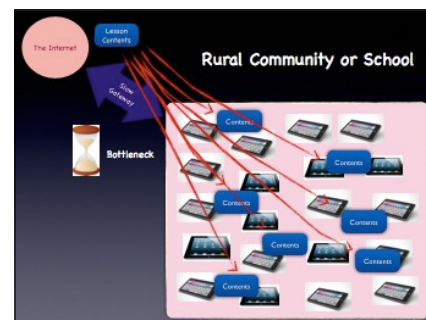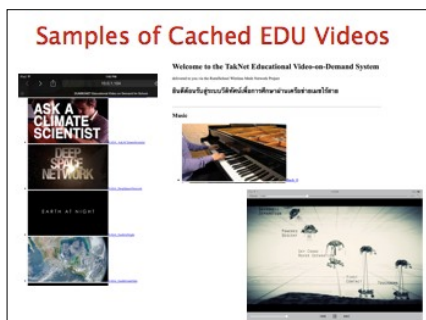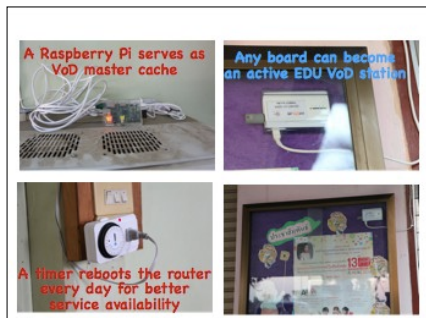

Our proposed solution

- We attempt to bring High-Definition (HD) Educational Video on Demand (VoD) experience to students in rural schools

- VoD requires a significant amount of network bandwidth. Therefore, video caching and cache management prove very important!

A school's installation of WMN nodes with EDU VoD

A Raspberry Pi serves as VoD master cache

Any board can become an active EDU VoD station

A timer reboots the router every day for better service availability

The art of "old" vs. "new" video on demand systems

Samples of Cached EDU Videos

Rural Community or School

Bottleneck

Alleviating the bottleneck problem (1)

Content Distribution Node

Alleviating the bottleneck problem (3)

near dawn

Alleviating the bottleneck problem (2)

mid night

Alleviating the bottleneck problem (4)

school's hours