UNIVERSITY OF CAMBRIDGE
Computer Laboratory

RasPiNet: Decentralised Communication and Sensing Platform

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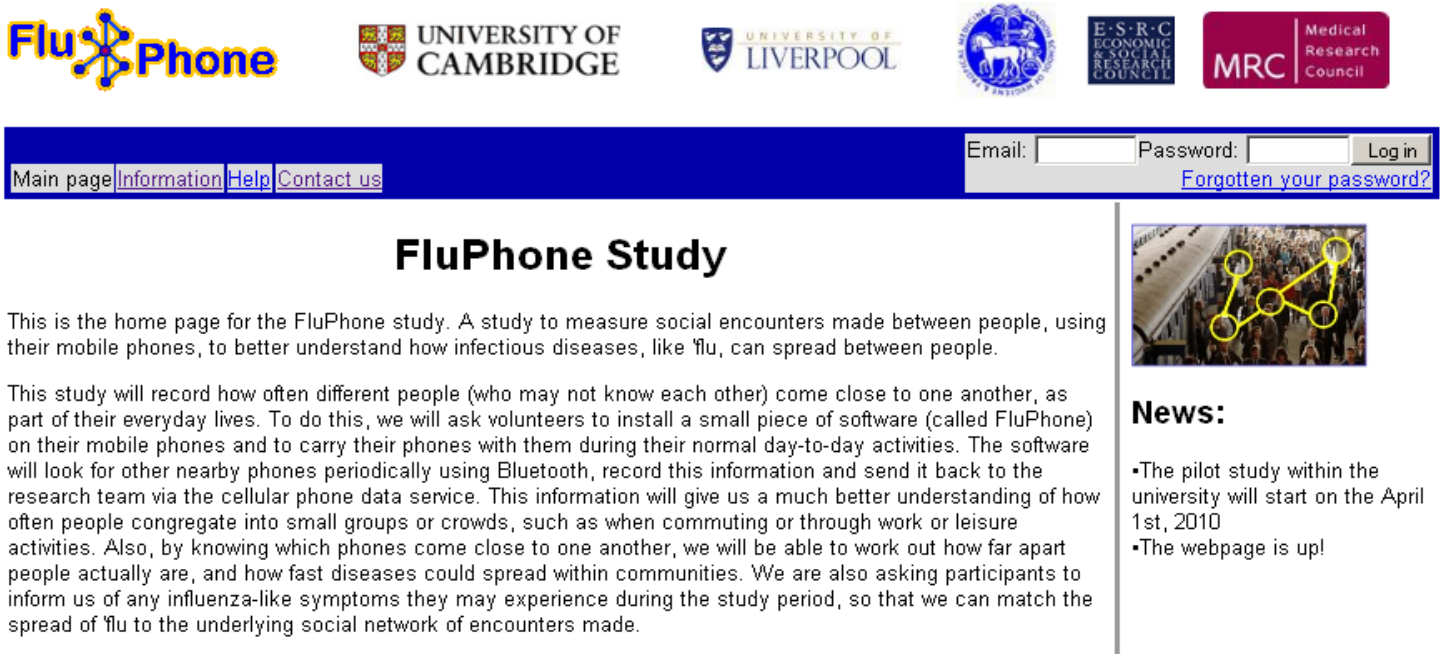
University of Cambridge Computer Laboratory

FluPhone Project

- Understanding behavioural responses to infectious disease outbreaks
- Proximity data collection by Bluetooth using mobile phone from general public in Cambridge together with Flu-like symptom report

https://www.fluphone.org



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FluPhone Study

This is the home page for the FluPhone study. A study to measure social encounters made be
their mobile phones, to better understand how infectious diseases, like 'flu, can spread betwee

This study will record how often different people (who may not know each other) come close to
part of their everyday lives. To do this, we will ask volunteers to install a small piece of software
on their mobile phones and to carry their phones with them during their normal day-to-day activ
will look for other nearby phones periodically using Bluetooth, record this information and send
research team via the cellular phone data service. This information will give us a much better u
often people congregate into small groups or crowds, such as when commuting or through wor
activities. Also, by knowing which phones come close to one another, we will be able to work
people actually are, and how fast diseases could spread within communities. We are also aski
inform us of any influenza-like symptoms they may experience during the study period, so that

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4 May 2011 Last updated at 17:49

FluPhone app 'helps track spread of infectious diseases'

A mobile phone application could help monitor the way infectious diseases such as flu are spread.

The FluPhone app was developed by researchers at the University of Cambridge Computer Laboratory.

Volunteers' phones filled with the app "talk" to each other, recording how many people each "infected subject" meets during an imaginary epidemic.

The FluPhone app tracks volunteer "infected subjects" using Bluetooth technology

The university is one of seven institutions working on the study to reduce the impact of epidemics.

The FluPhone app uses Bluetooth technology to anonymously record interaction between volunteers involved in the study.

When mobile phones come into close proximity, that fact is recorded and data is sent automatically to the research team.

Related Stories

Web surveillance maps global disease trends

'Valuable insight'

Professor Jon Crowcroft and Dr Eiko Yoneki, co-principal investigators of the study, said they believed the collected data could be used to simulate social interaction during a real epidemic or pandemic.

A three-month FluPhone pilot study, using a basic version of the app, was conducted in Cambridge in 2010.

Dr Yoneki said: "The data was a valuable insight into how human communities are formed, how much time people spend together, and how frequently they meet.

"Such data show complex network-like structures, which is very useful for understanding the spread of disease."

Prof Crowcroft explained epidemiologists traditionally monitor how a disease spreads by asking patients to keep diaries of their movements and social contacts.

"That's very heavy-going and people often forget to do it, or forget who they've met," he said.

The FluPhone app was, he explained, a more reliable way to record contact between "infectious subjects".

Monitoring behaviour during a simulated epidemic could help prevent the disease spreading

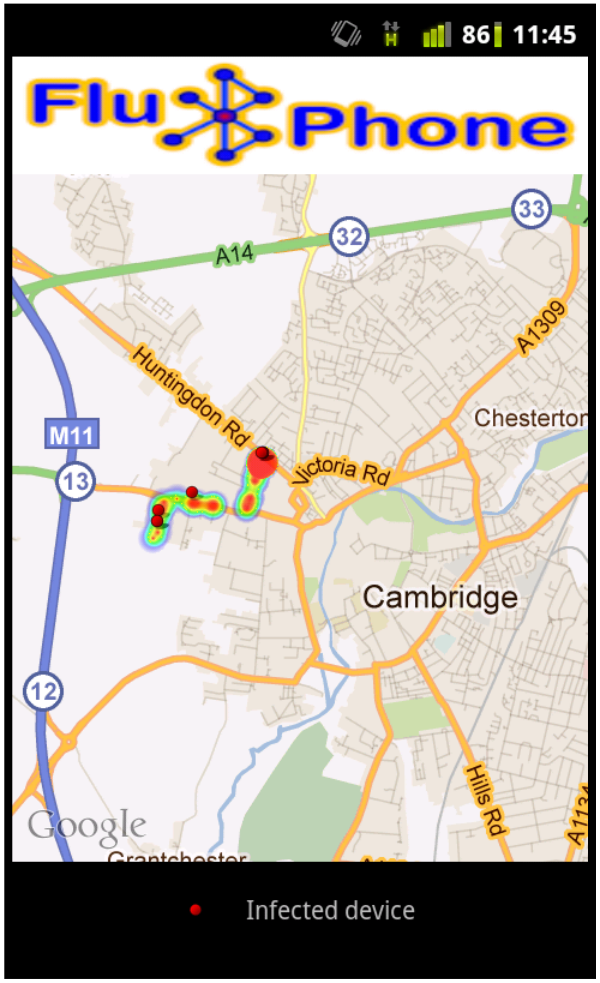
"Provided we have people's permission, we can upload the data, and medical researchers can see who met whom within the set of volunteers, without there being any missing encounters.

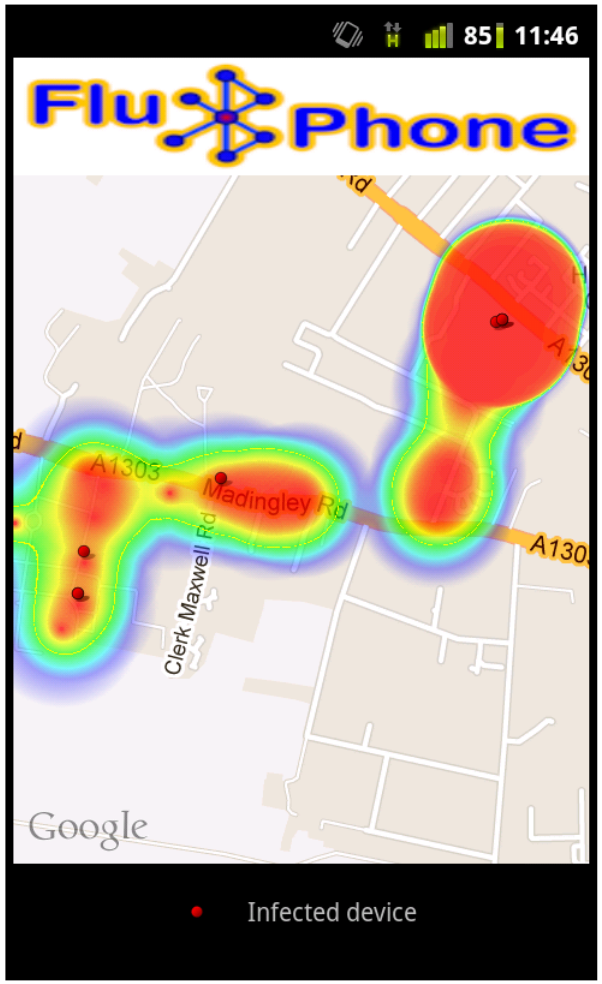
FluPhone

- Scan Bluetooth devices every 2 minutes (today's experiment)

Trajectory of Encountering Sick People

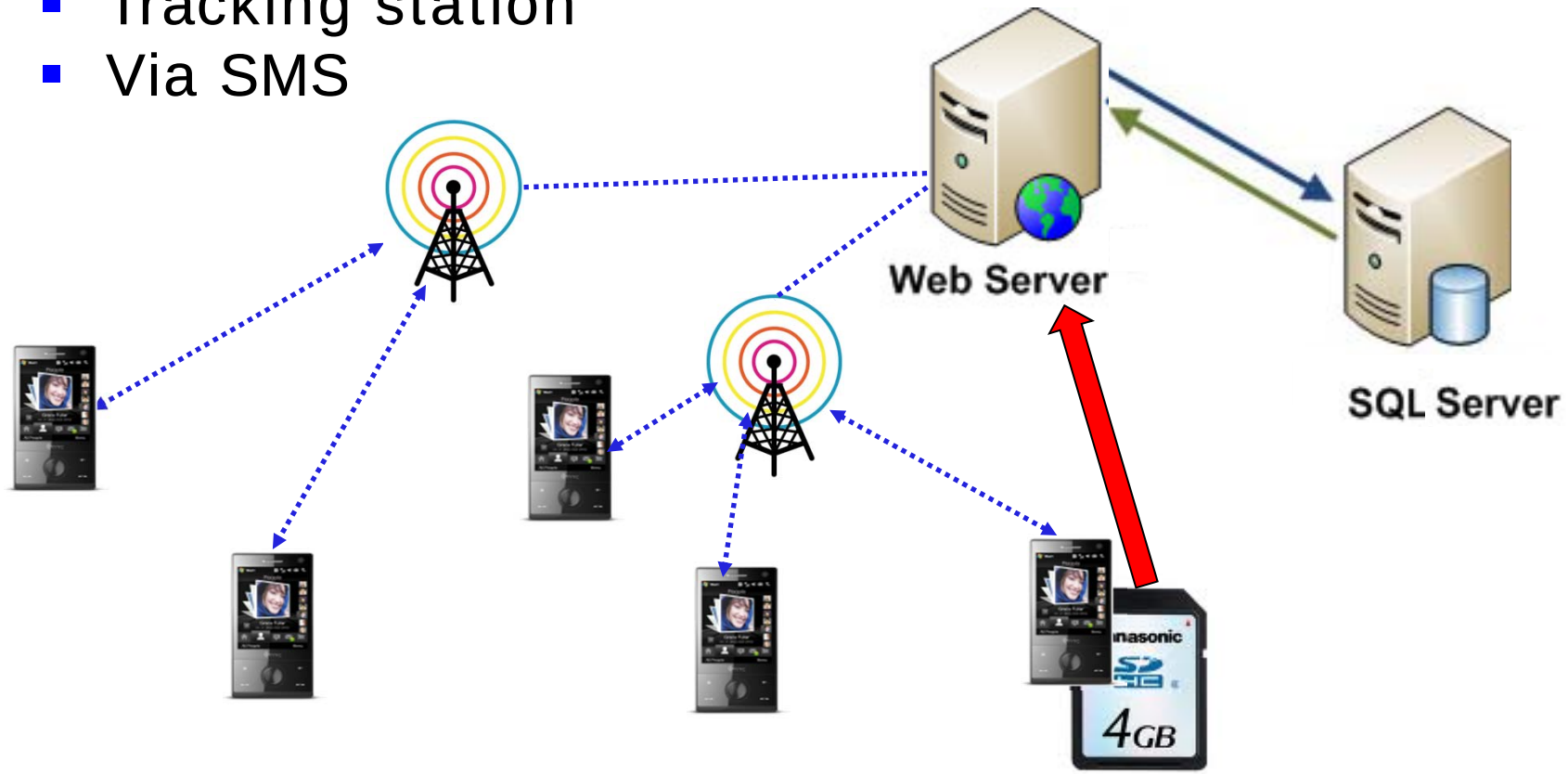
- Integration with GPS equipped Smartphones





FluPhone – Data Collection

- Via GPRS/3G FluPhone server collects data
- Uploading via Web
- via memory card
- Tracking station
- Via SMS



Issues on Data Collection in Africa

- No infrastructure based Internet access
- No need to have end-to-end steady connection
- Forward data to where data analysis can be performed
- Experimental data collection may need to be repeated many times with different configurations

Sensing Platform in Remote Region

- Build a platform for sensing and collecting data in developing countries
  - e.g. OpenBeacon Active RFID tags based contact network data collection
  - Build a standalone network for data collection and communication using Raspberry Pi
  - Inexpensive network setting
  - General purpose Raspberry Pi communication platform RasPiNET
    - Support streaming model

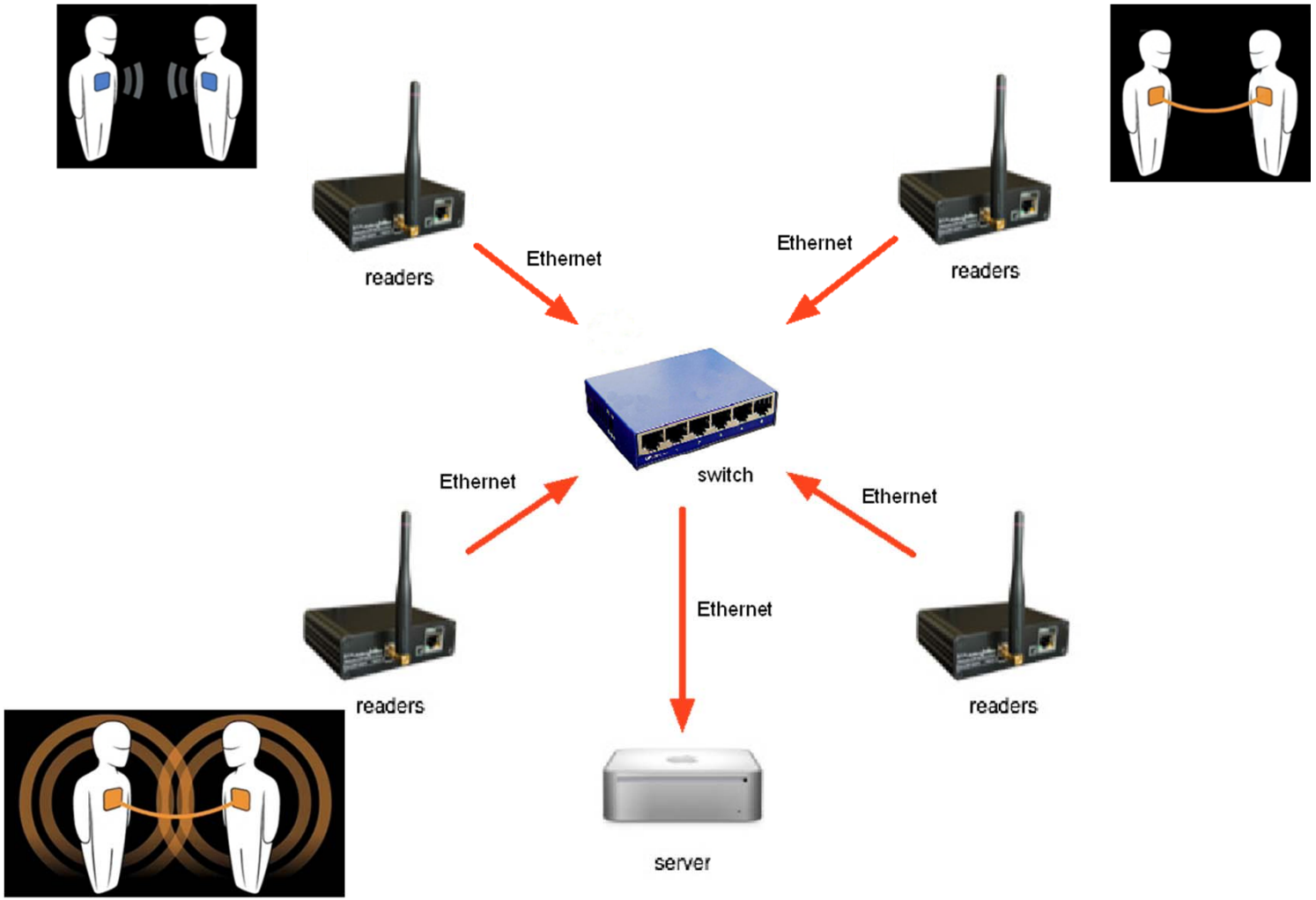
OpenBeacon RFID Tags

- OpenBeacon Active RFID Tags
- Bluetooth has an omnidirectional range of ~10m
- OpenBeacon active RFID tags: Range ~1.5m and only detect other tags are in front of them
- Low Cost ~=10GBP
- Face-to-Face detection
- Temporal resolution 5-20 seconds
- On-board storage (up to ~4 logs)
- Batter duration ~2-3 weeks

An OpenBeacon RFID tag

OpenBeacon Ethernet EasyReader

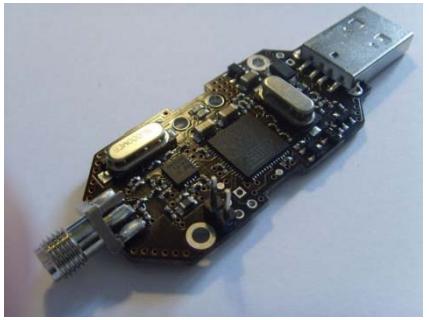
RFID Tag with Ethernet Readers



Raspberry Pi based Reader

- OpenBeacon Ethernet Readers need Ethernet connection (Cannot be deployed outside)

→ Using USB based reader with Raspberry Pi

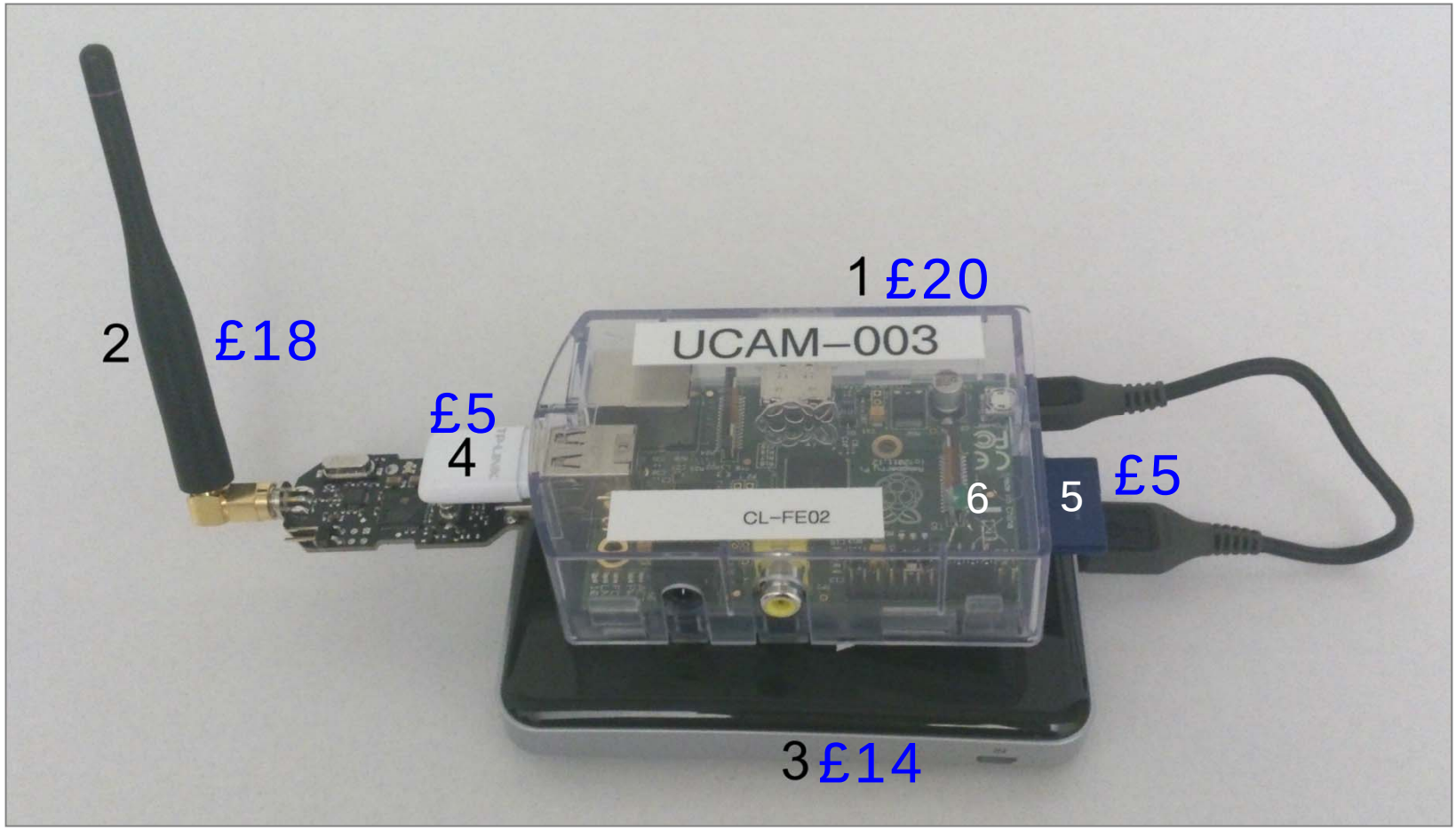


OpenBeacon USB Reader

- USB reader + Raspberry Pi
  - Raspberry Pi (700MHz ARM11 CPU, 512MB RAM, 2 USB ports, SD card port, Ethernet port)
  - WiFi connectivity
  - Mobility (w/ battery pack)
  - Work without a server – SD card storage
  - Show the status of RasPi (GPIO and a LED) - blinks differently depending of:
    - Pi is synced to correct time
    - Successfully sent the data

TP-Link TL-WN723N Wifi Dongle

Epi-Pi: Raspberry Pi OpenBeacon Reader



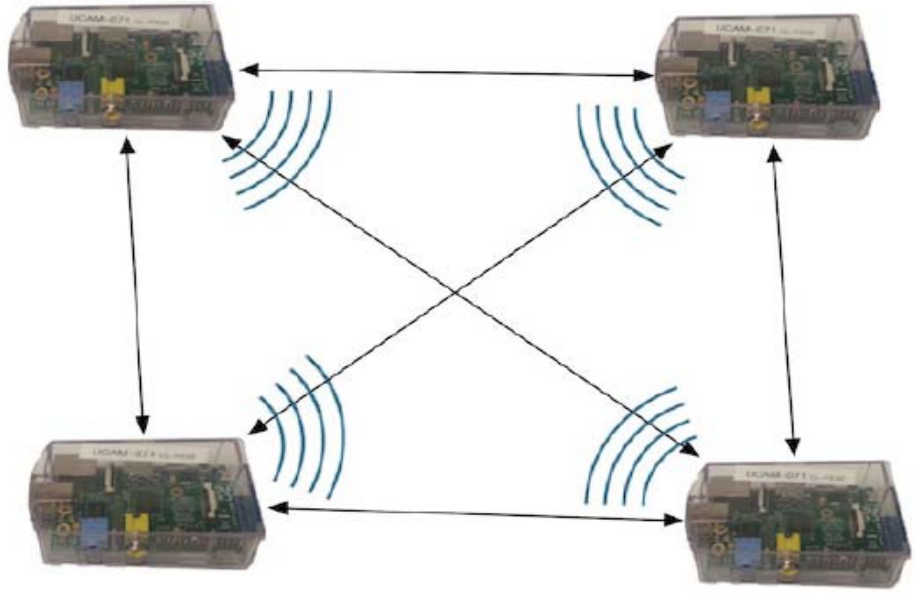
1. Raspberry Pi
2. OpenBeacon USB reader
3. Battery Pack (7000mAh)
4. WiFi dongle
5. SD Card
6. LED

RasPiNET: RasPi Communication Platform

- Raspberry Pi can be deployed almost everywhere
- Data Collection:
  - With WiFi access
  - RasPi SD card: data can be stored for months and latter processed
  - With WiFi Data Mule
- RasPiNET can form Distributed Computing Platform

Option for WiFi Configuration

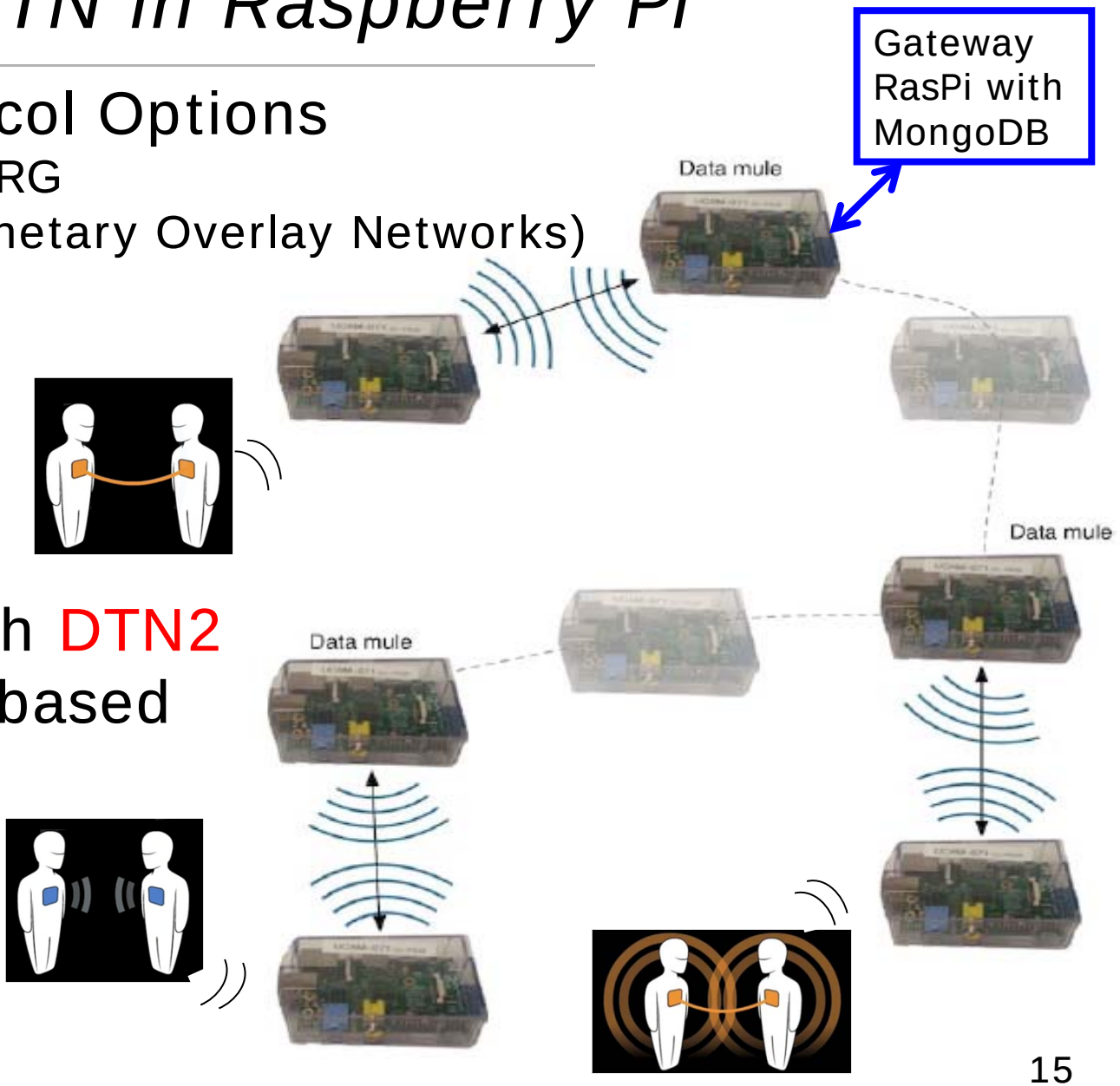
- Use USB WiFi dongle to setup WiFi Adhoc communication → High energy consumption



- Software Access Point: One Raspberry Pi acts as Access Point and the others as Clients
- WiFi Direct: All the devices can communicate each other → Reducing energy consumption

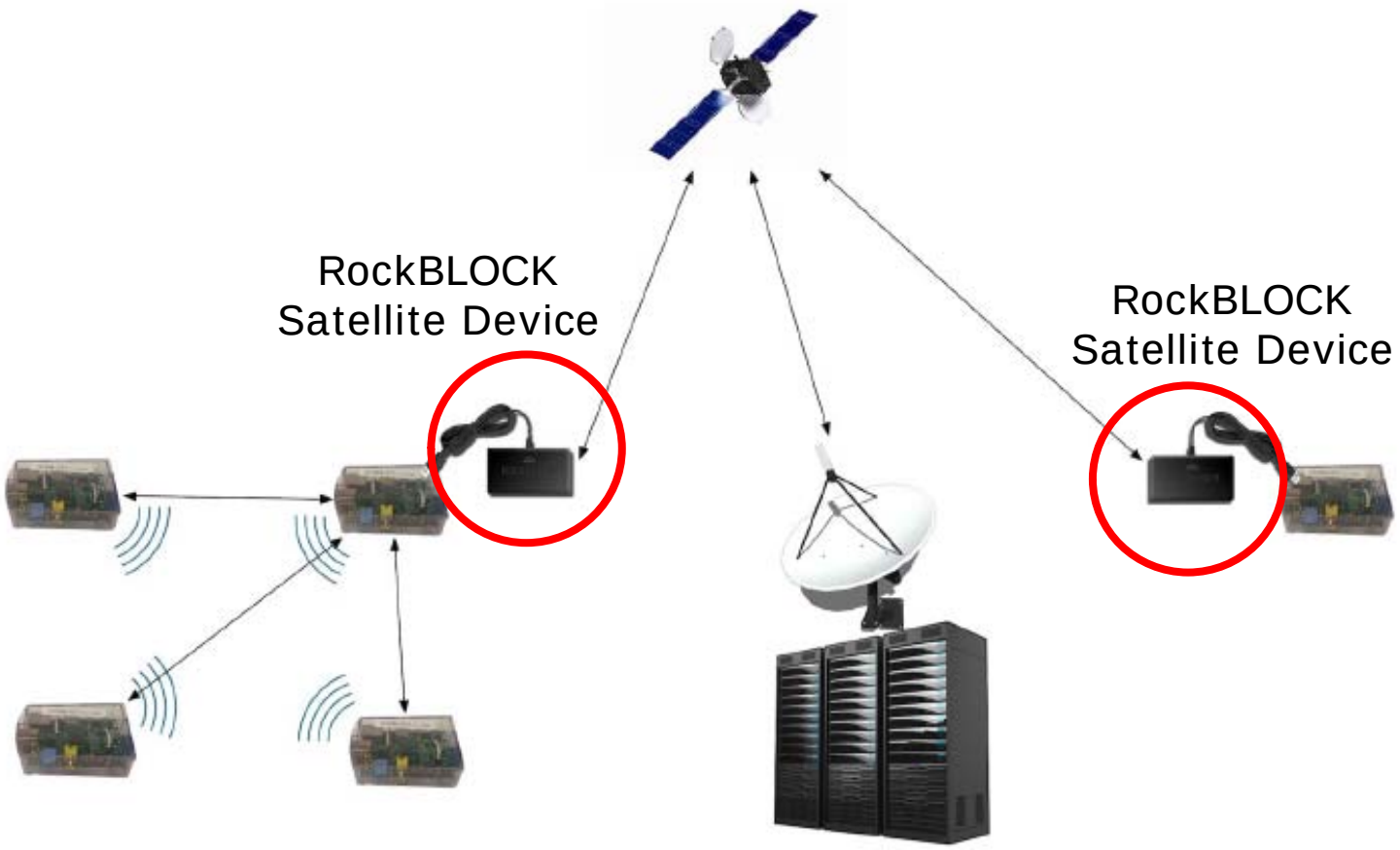
DTN in Raspberry Pi

- Bundle Protocol Options
  - DTN2 by DTNRG
  - ION (Interplanetary Overlay Networks)
  - IBR-DTN
- RasPiNET with DTN2
- Software AP based Data Mule



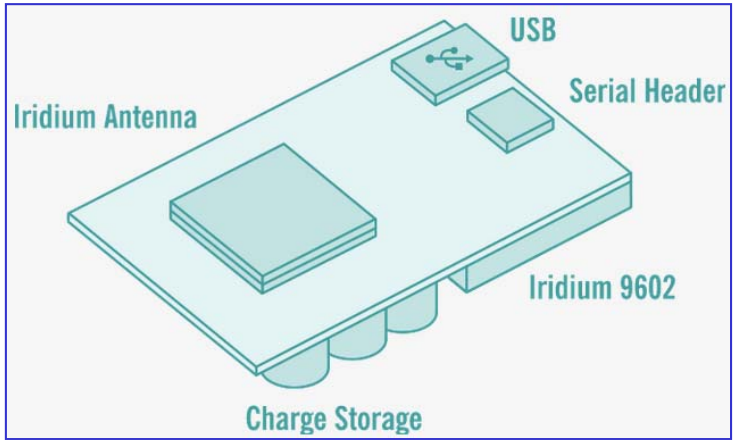
RasPiNET with Satellite Communication

- Satellite module is integrated
- Useful in developing country



Satellite Communication

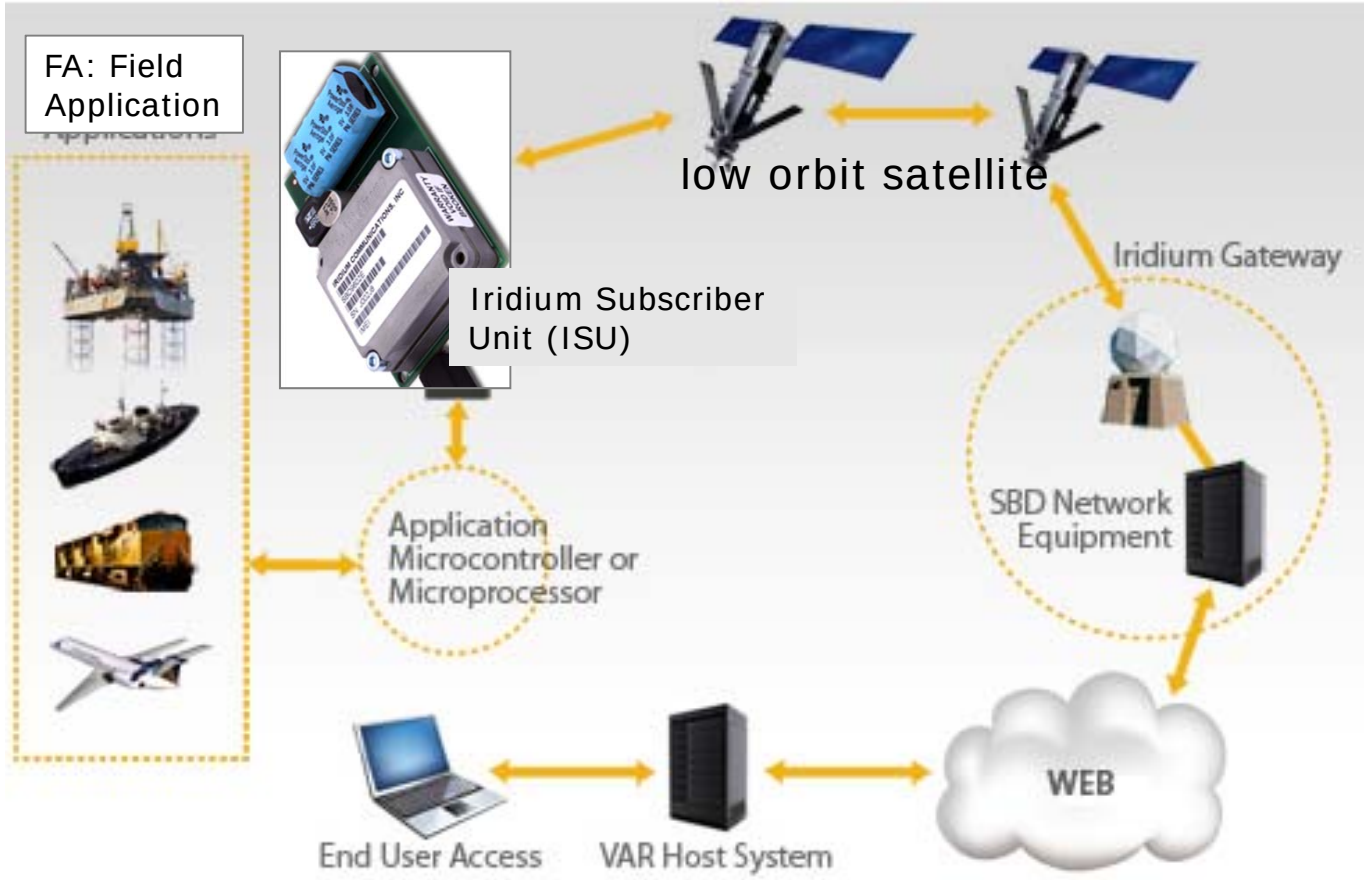
- Satellite module integration in Raspberry Pi
  - RockBLOCK Satellite Module (~=£120)
  - Uses Iridium Satellite Network: Short Burst Data(SBD)
  - Iridium SBD session roughly every 10 seconds
  - To email address, or own web service (i.e. HTTP POST)
  - pay-as-you-go – 34 bytes per message (Hex encoded)
    - 50 credits - 12p/message
    - 20000 Credits – 4p/message



RockBLOCK satellite module

Iridium SBD

- Interface between FA and ISU is a serial connection with extended proprietary AT commands
- Interface is used to load/retrieve messages
- Available 24/365 from any coordinate on the earth



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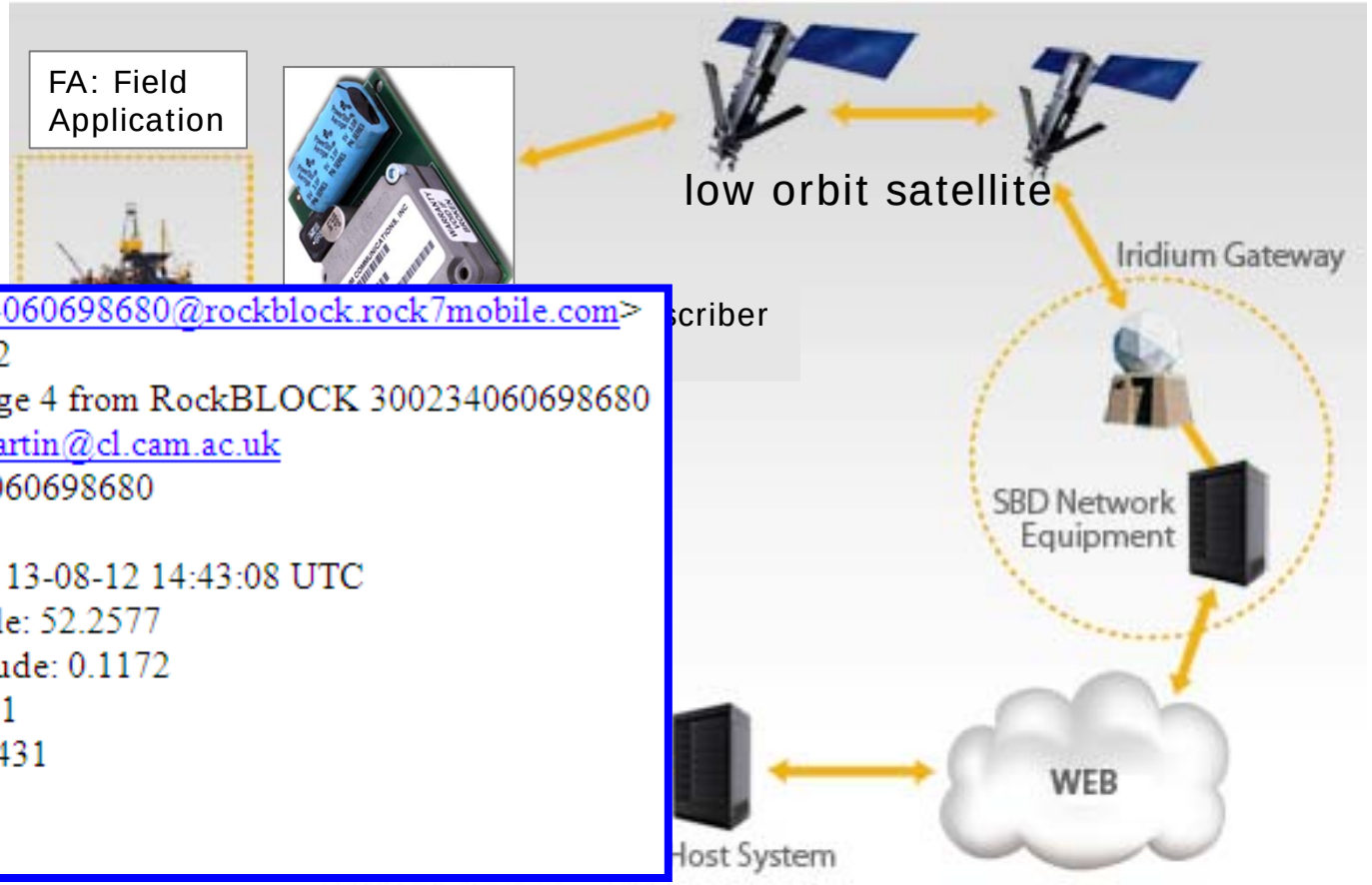
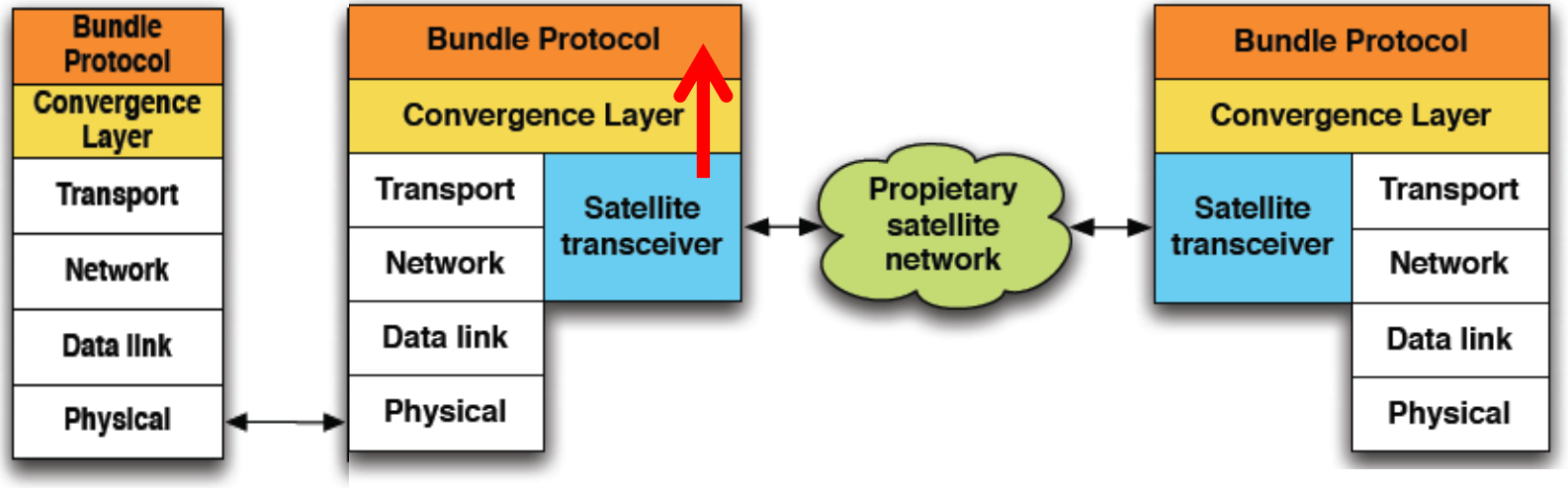


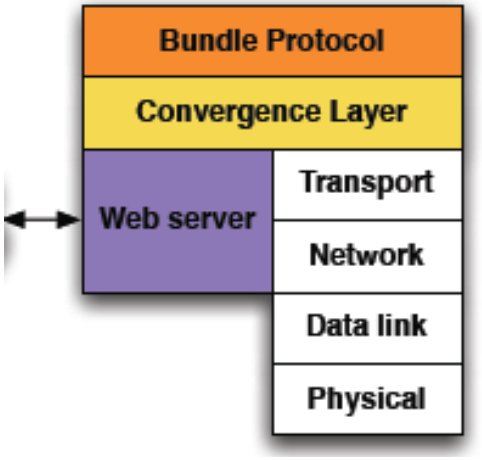
From: <300234060698680@rockblock.rock7mobile.com>
Date: 2013/8/12
Subject: Message 4 from RockBLOCK 300234060698680
To: abraham.martin@cl.cam.ac.uk
IMEI: 300234060698680
MOMSN: 4
Transmit Time: 13-08-12 14:43:08 UTC
Iridium Latitude: 52.2577
Iridium Longitude: 0.1172
Iridium CEP: 11
Data: 7465737431
--
test1

Communication Protocol

- Protocol for communication between devices with satellite transceiver



- Rockblock provides Web Service Interface
- also Email Interface



Data Compression

- Message to Iridum network < 340 bytes
- Received message < 270 bytes every 10 seconds
- Currently DTN2 not ION
- Additional compression and fragmentation protocols are needed that are not included in the default stack of communication

- Raspberry Pi has ability of data processing
  - Future plan – in-network data aggregation and processing

Simulator

- Simulation of RaspiNET together with a satellite connection (w/o real satellite simulation part)
- One simulator (http://www.netlab.tkk.fi/tutkimus/dtn/theone)

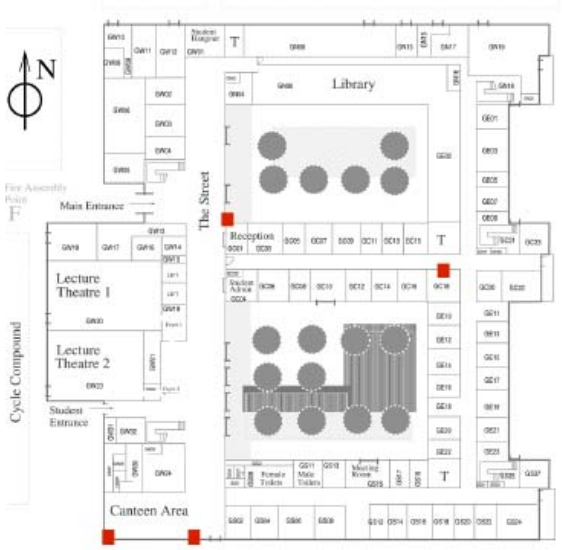
Pilot Study in Computer Laboratory

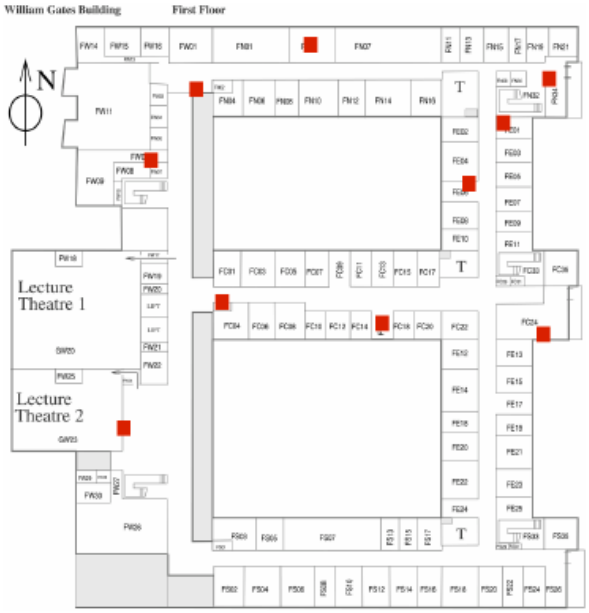
- 15 RasPi OpenBeacon Readers around Computer Laboratory
- 30 participants (4 groups)
- 3 days of data collection

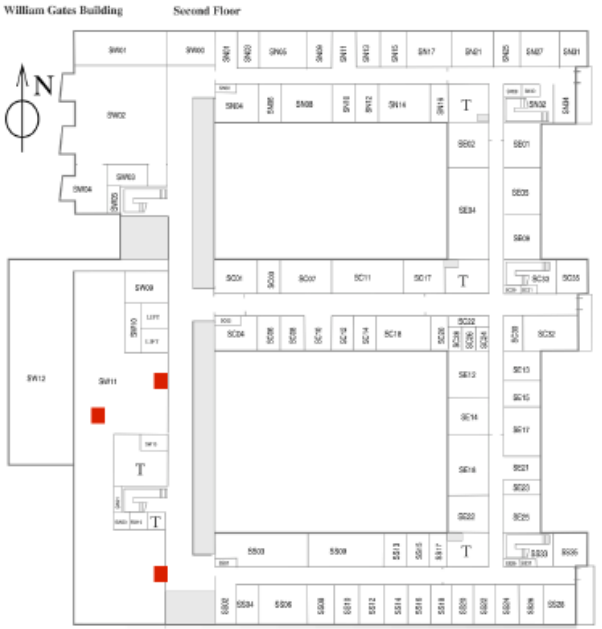
A participant wearing three RFID tags

Setting RasPiNET on 3 Floors

- Use of Data Mule approach for Data Collection
- Satellite Communication for sending statistics and changing sensing rate

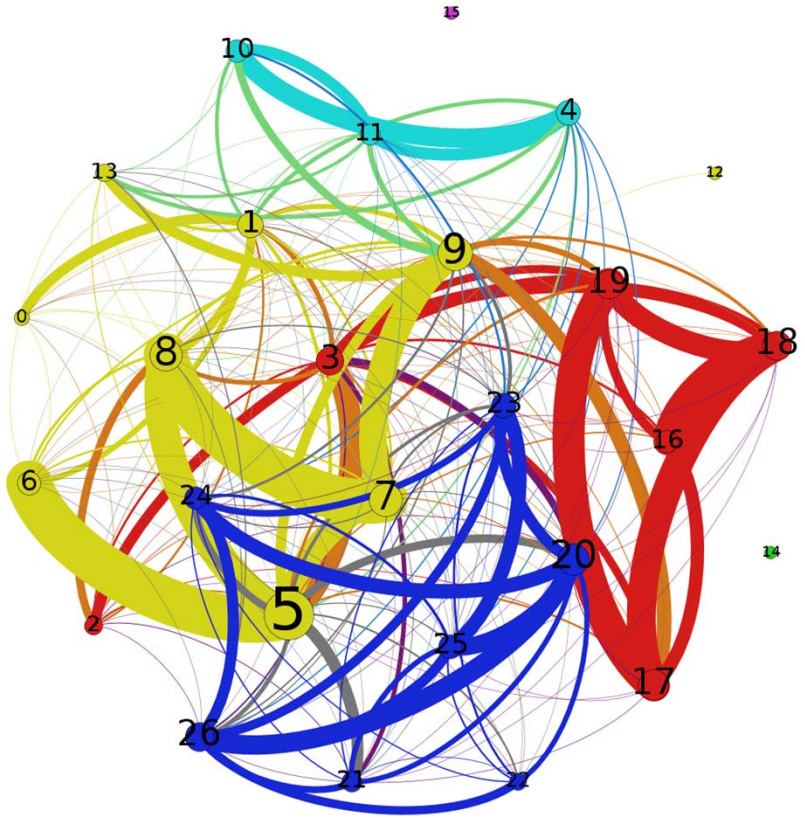






Post Data Analysis on Pilot Study

- Community Detection (4 groups and bridging nodes can be identified)



RasPiNET: Summary

- Raspberry Pi: Great Support by Computer Lab
  http://www.cl.cam.ac.uk/projects/raspberrypi/
- Built DTN with Raspberry Pi
  - Can deploy sensing and crowd sourcing platform dynamically – deployable outside and remote location
  - Use satellite connectivity (all nodes or gateway nodes)
  - Distributed computation platform
- Future Challenges
  - Compress data for light-weight communication plus in-network data aggregation and processing (i.e. Raspberry Pi - mini data centre)
  - Build Programming API for both whole system and local sensing sides (e.g. Streaming Platform)
- Summer 2014 Plan
  - RasPiNET network capacity and scalability study
  - Overhead study on satellite communication by RockBlock
  - Larger scale real world experiment of RFID based proximity sensing
  - Adding multicast (publish/subscribe) feature

Epidemiology Study Plan

- University of Cambridge Nurseries
  - Schools – Together with RasPi School Tutorials
- Data Collection in Developing Countries
  - Possible study in Africa (Botsuwana, Gabon, Congo)
  - Support various proximity sensing techniques
    - Collect medical symptoms
    - Capture surrounding context (e.g. temperature, light, humidity, GPS-location)
  - Combine diary and interview Survey
- Support effective vaccination strategies within limited budget in developing countries