Smart participatory networks

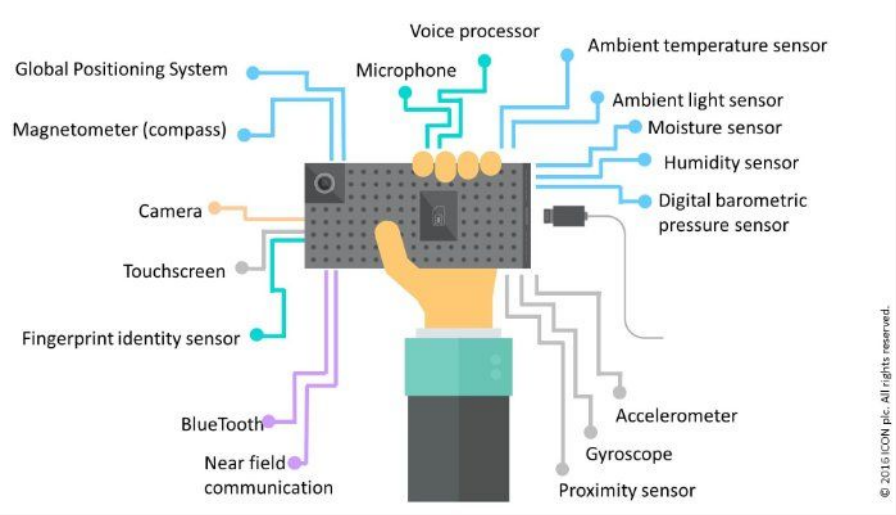
Radu-Ioan Ciobanu
Faculty of Automatic Control and Computers
University Politehnica of Bucharest
radu.ciobanu@cs.pub.ro

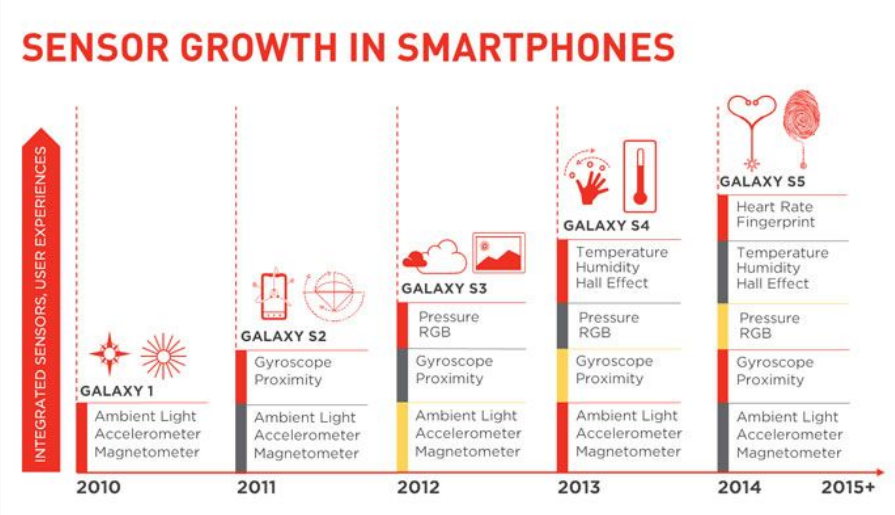
Introduction

Introduction

- About our organization
  - founded in 1818, **University Politehnica of Bucharest** is the oldest and most prestigious technical university in Romania
  - UPB offers B.Sc., M.Sc., and Ph.D. programmes in **17** fields of science and engineering to over **25,000** students
  - the University houses **37** Research Centres
  - pervasive and mobile services lab
  - http://www.upb.ro/en/
  - http://acs.pub.ro/en/

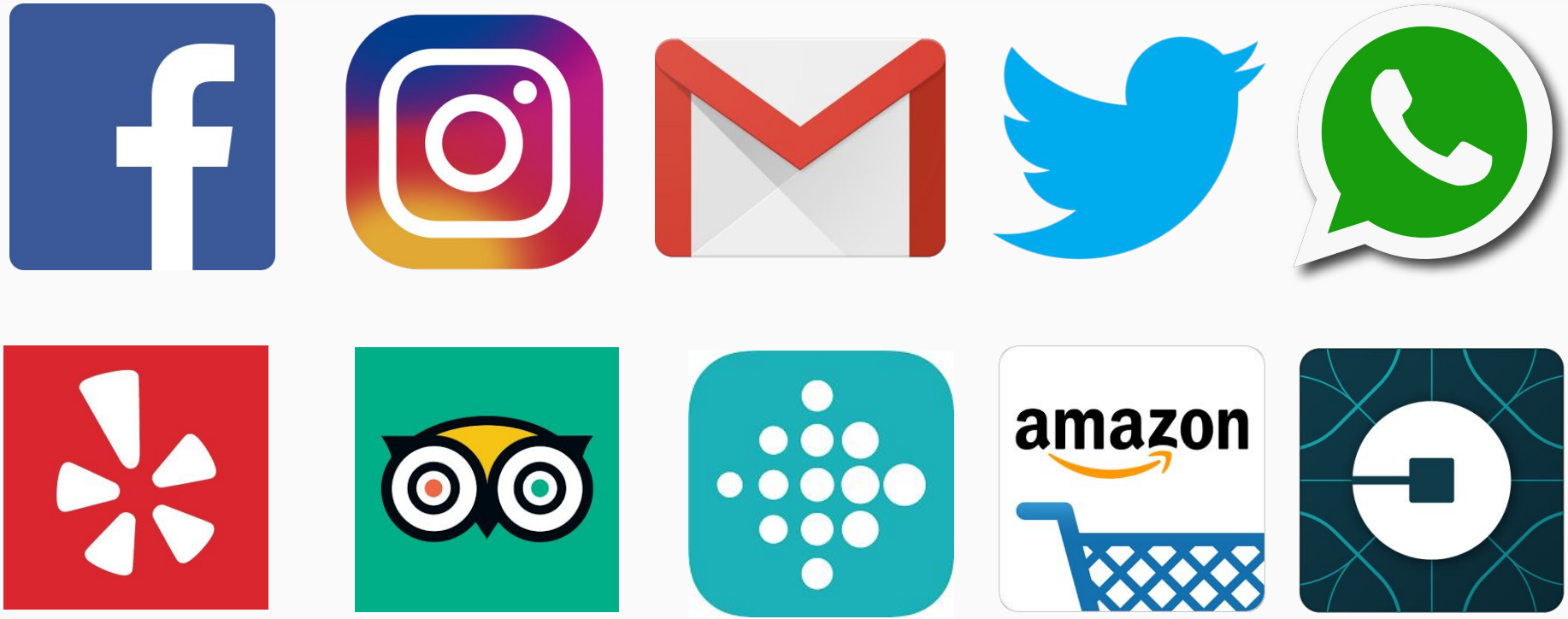
What can we do with a smartphone?





Smartphones collect a large amount of information about their users' status...

What can we do with a smartphone? (2)



… but also about their preferences and interactions.

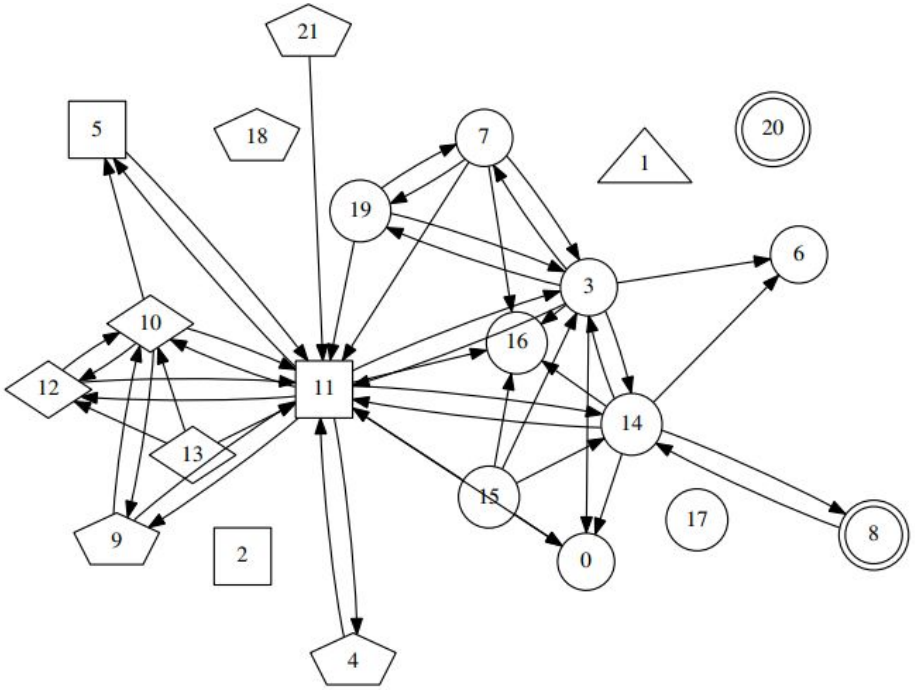
A socially-aware world

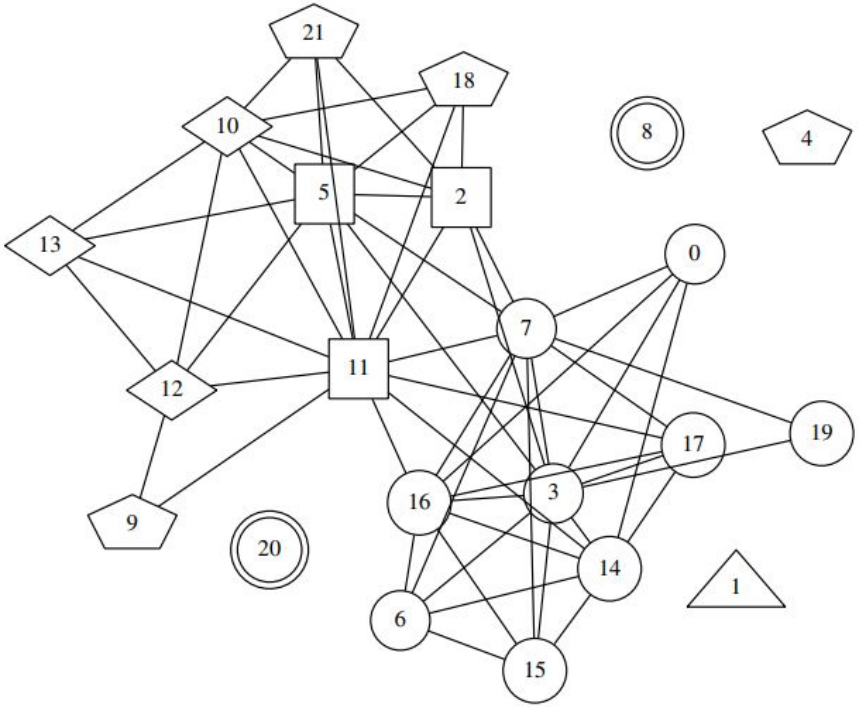
- Human mobility and behavior can be deduced from **online** and **offline** social networks interactions
- Mobility traces
  - UPB 2011[1]
    - Android application (Social Tracer)
    - Bluetooth
    - 35 days
    - 22 participants (students and faculty members)
  - UPB 2012[2]
    - Android application (HYCCUPS Tracer)
    - Bluetooth and AllJoyn (Wi-Fi)
    - 64 days
    - 58 participants (students and faculty members)
  - Contain **social** information and **interests** data

[1] http://crawdad.org/upb/mobility2011/20120618/
[2] http://crawdad.org/upb/hyccups/20161017/

A socially-aware world (2)

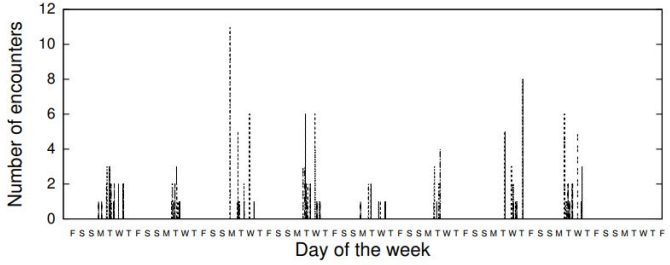
- Offline vs. online communities



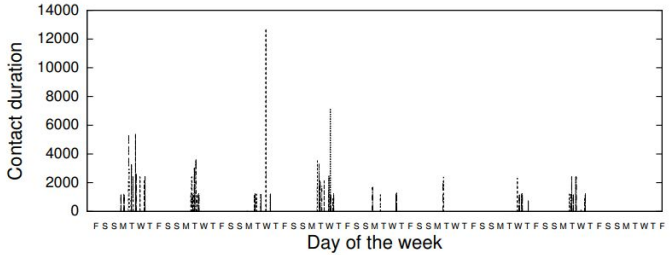


Towards a network of opportunities

- Social grouping information can be used to **predict** node behavior
- Other context data can also be employed (interests, location, etc.)

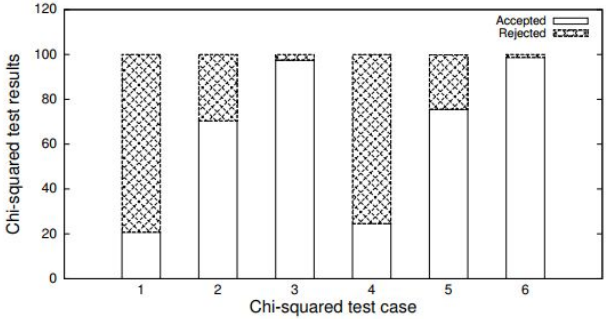


(a) Encounters

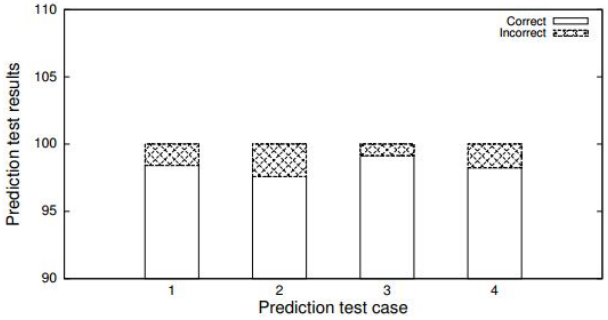


(b) Contact durations

Total encounters and contact durations per day for a random node



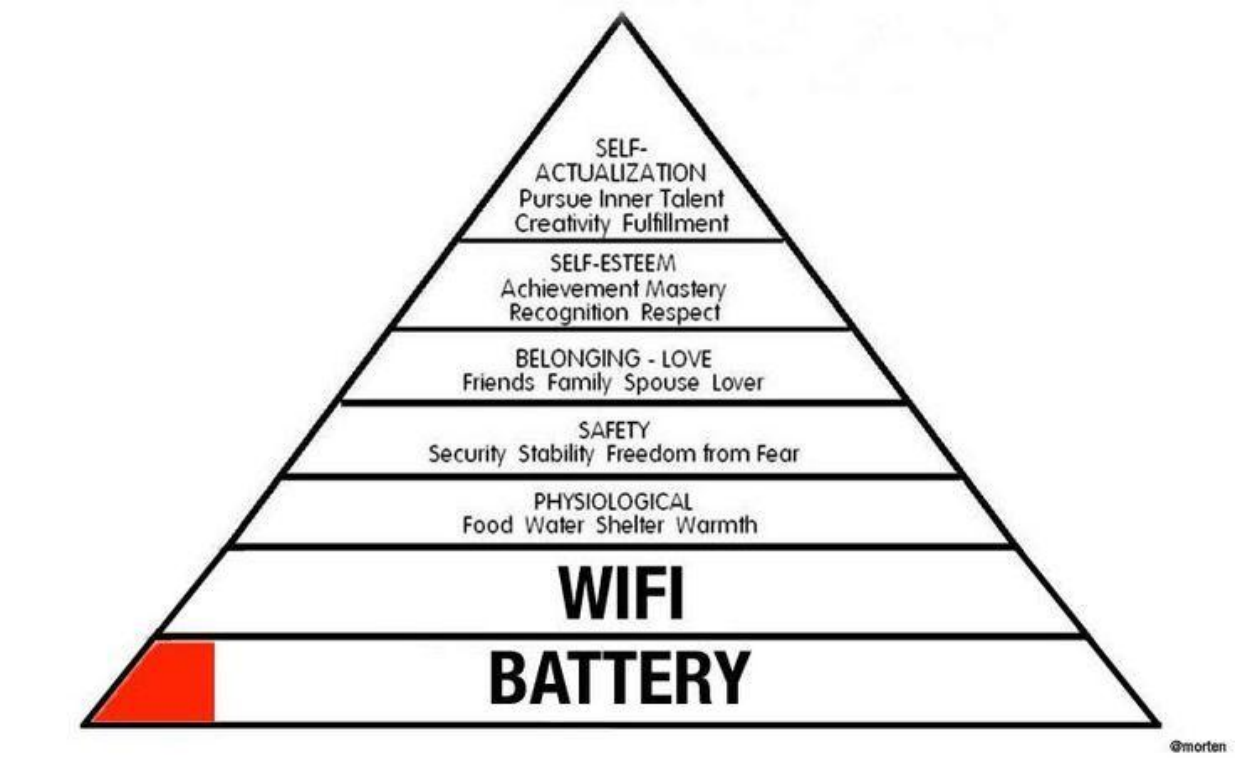
(a) Chi-squared



(b) Prediction success

Chi-squared test results and prediction success of the Poisson distribution; for the chi-squared tests, datasets 1, 2 and 3 are computed using the total number of encounters and varying the max likelihood (1 – for the entire experiment, 2 – per weekday, 3 – per hour of a day of the week), while datasets 4, 5 and 6 are computed using unique encounters; for the prediction success, datasets 1 and 2 are computed using the total number of encounters (1 – the next to last week, 2 – the last week) and datasets 3 and 4 are computed using unique encounters

Motivation


SELF-
ACTUALIZATION
Pursue Inner Talent
Creativity Fulfillment
SELF-ESTEEM
Achievement Mastery
Recognition Respect
BELONGING - LOVE
Friends Family Spouse Lover
SAFETY
Security Stability Freedom from Fear
PHYSIOLOGICAL
Food Water Shelter Warmth
WIFI
BATTERY
@morten

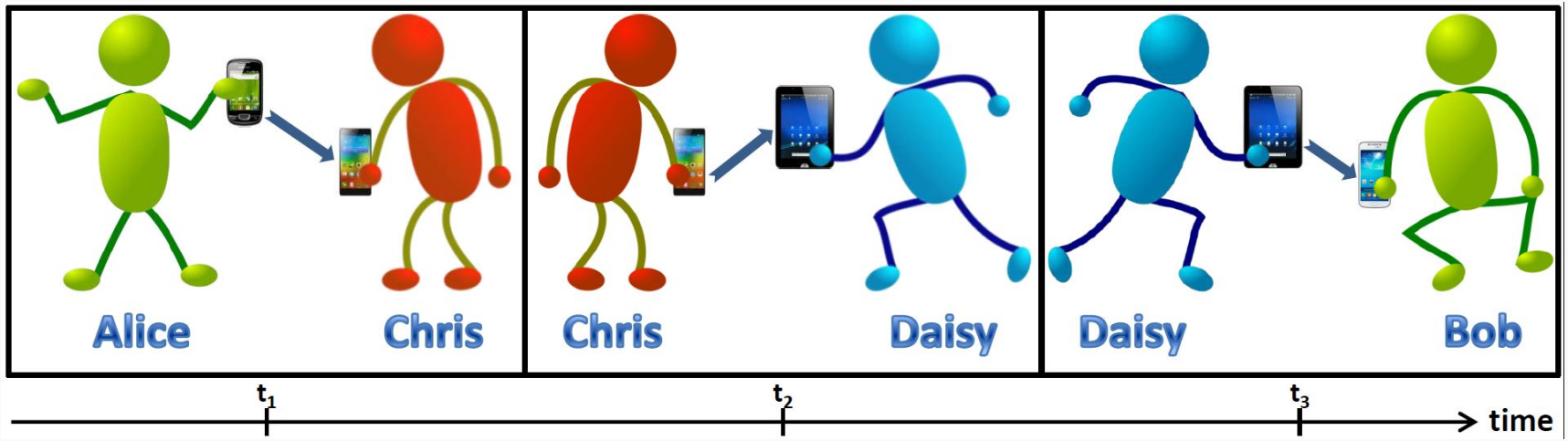
Motivation (2)

- Mobile devices constantly generate large amounts of data
  - they do not necessarily have the capabilities of processing all data themselves
  - uploading to the Cloud can prove costly (in terms of battery, data plan, etc.)
  - **what if devices in close range can help with the processing?**
  - **what if data can be aggregated with information from close-range devices?**
- Mobile devices also constantly require information and computations from the Cloud
  - costly to communicate back and forth with the Cloud
  - **what if the required data is already close at hand?**
  - **what if somebody else nearby can help with the processing?**

Opportunistic networks

Definition

- Natural evolution of **MANETs**, where most of the nodes are **mobile wireless devices**
- Composing nodes have no knowledge of the shape of the network when they join it
- Follow the **store-carry-and-forward** paradigm
- Based on node **altruism**



Support technologies

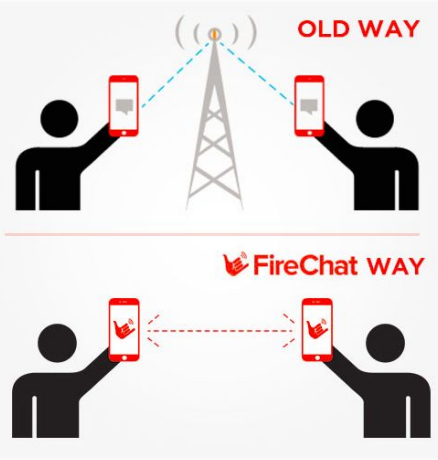
- Communication through **close-range protocols**
- No wireless or mobile broadband connection

Metric	Bluetooth	BT Smart	NFC	ZigBee	LoRa	Wi-Fi Direct	Wi-Fi	3G	4G
Infra-structure	No	No	No	No	Yes	No	Yes	Yes	Yes
Max range (m)	100	50	0.2	100	2200	200	100	1000+	1000+
Speed (Mbps)	2.1	1	0.4	0.25	0.05	250	600	28	300
Power	1	0.05	0.05	0.33	0.05	33	33	16	20
Security	WPA2	AES	N/A	AES	AES	WPA2	WPA2	KASUMI	SNOW 3G

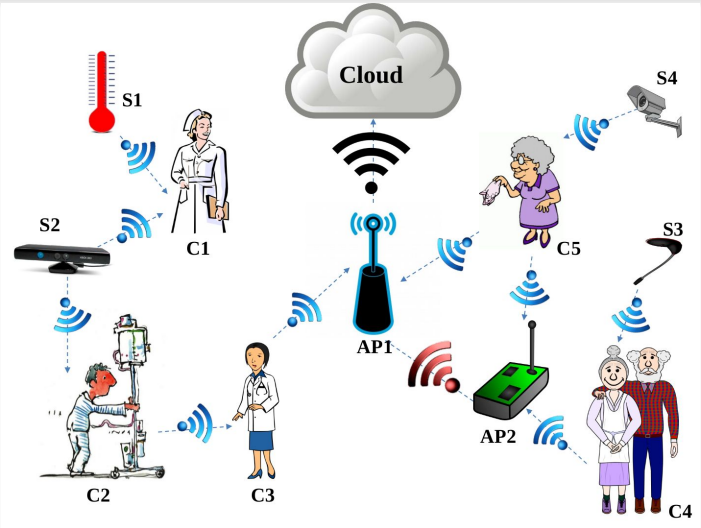
Use cases

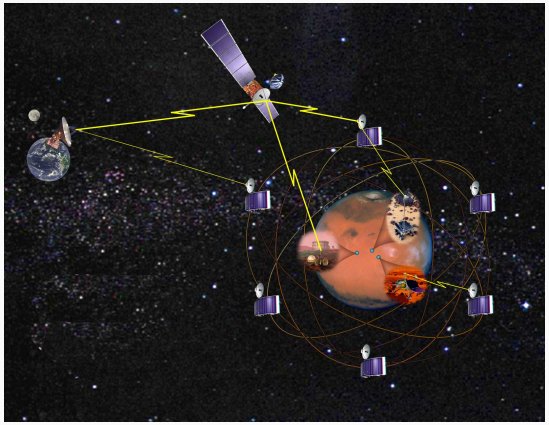

Loon
for all


Smart care
Smart Society
Smart building
Smart Energy
Smart Working
Smart Retail
Smart Home
Smart Mobility


OLD WAY
FireChat WAY

Use cases (2)


Cloud
S1
S2
S3
S4
C1
C2
C3
C4
C5
AP1
AP2

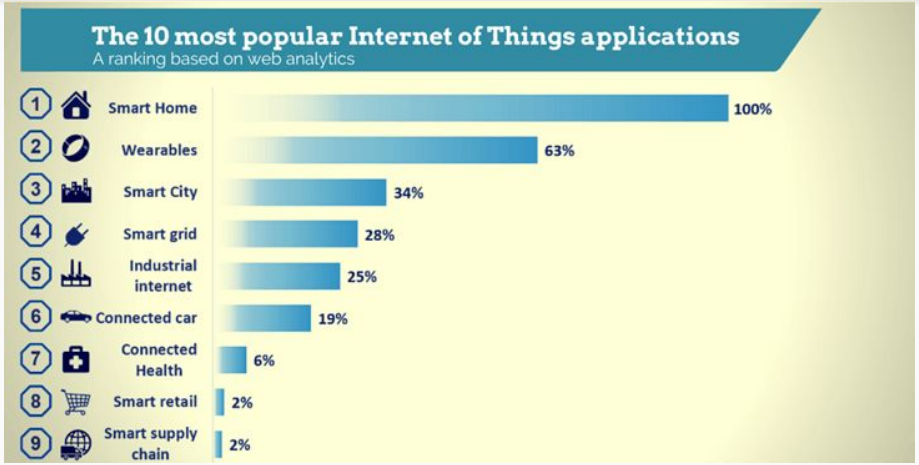



FREE
25%
ADMIT ONE
SALE
50%


WEMBLEY
CONNECTED BY EE

The Internet of Things

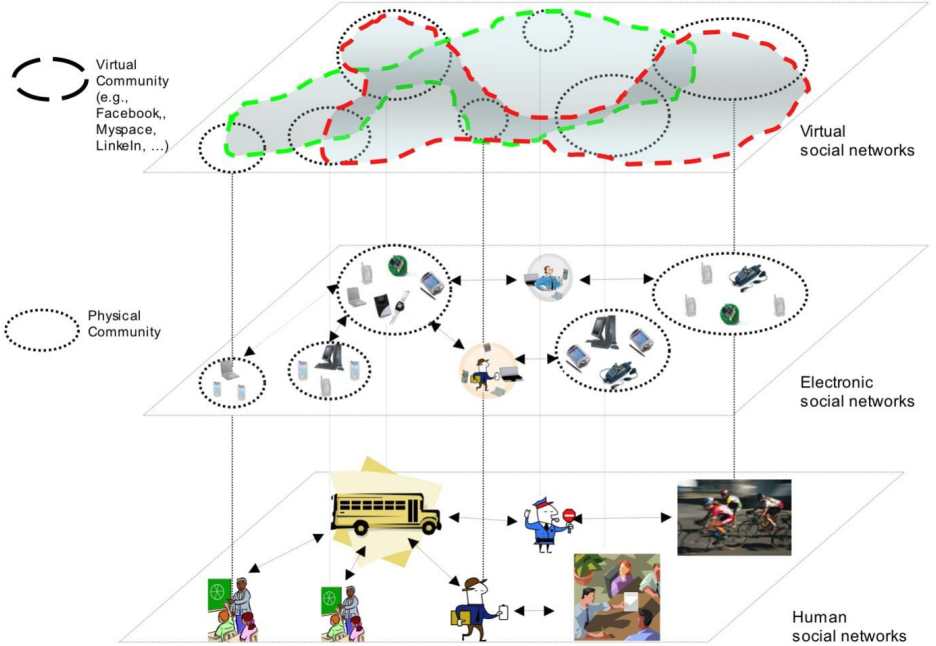
- Inter-networking of
  - physical devices
  - vehicles
  - buildings
  - items embedded with
    - electronics
    - software
    - sensors
    - actuators
    - network connectivity, etc.



- Offers advanced connectivity of devices, systems, and services beyond machine-to-machine (M2M) communications
- Covers a variety of protocols, domains, and applications
- Generates **large amounts of data** from diverse locations
- There is a necessity for quick **aggregation** of the data, and an increase in the need to **index**, **store**, and **process** such data more effectively

Design paradigms

- Epidemic routing is too **costly**
- Topological information is not precise at all, it must be complemented with **context** information
- Exploit high-level **context** information to infer user behaviour
- From network of physical devices to network of people



Challenges

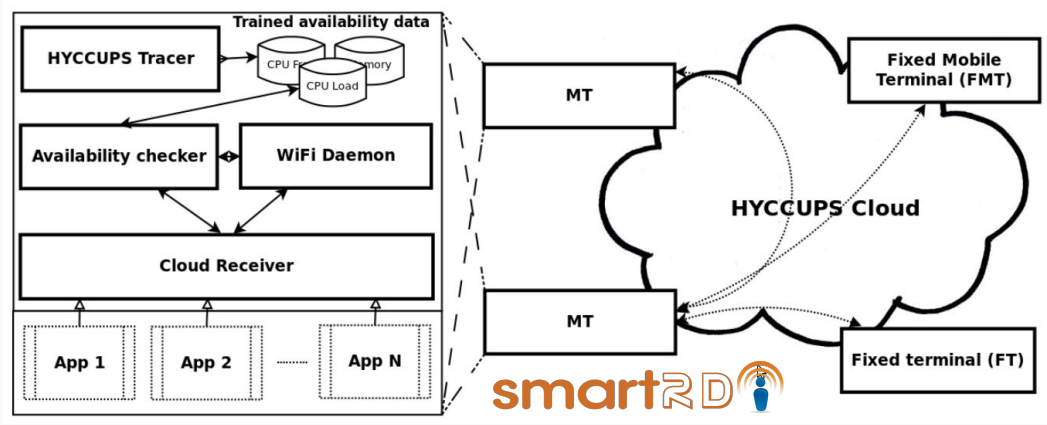
- **Lack of connectivity leads to lack of end-to-end paths**
  - Select next hop by making informed decisions using context data (contact history, social information, location, etc.)
  - **ONSIDE** - OpportuNistic Socially-aware and Interest-based DissEmination
- **Congestion and traffic overhead lead to higher energy consumption**
  - Choose next hops that have higher chances of delivering data than other nodes (predict node behavior)
  - **SPRINT** - Social PRedIction-based routing in opportunistic NeTworks

Challenges (2)

- **Long and variable delay, asymmetric data rates, lack of reliability**
  - Send data on multiple paths
- **Lack of privacy and security**
  - Use trust and reputation mechanisms, encrypt data
  - **SENSE**, **SPRINT-SELF**
- **Nodes only have locally collected knowledge**
  - Spread data between nodes through gossiping
- **Achieve real “mobile computing” without the need for a connected network**

Looking to the future

- Ubiquitous computing framework which offers smartphone devices the opportunity to collaborate over high-speed wireless networks in a distributed and transparent manner
- Use smartphones as both the computing resources, but also as the clients in a hybrid cloud
- Employ a contextual search method to determine if a workload should run remotely or locally
- Offload the current task to the best candidate in the mobile cloud as to reduce the power consumption while preserving the quality of experience



Thank you!

radu.ciobanu@cs.pub.ro