Network Driven Behaviour Modelling for Designing User Centred IoT Services

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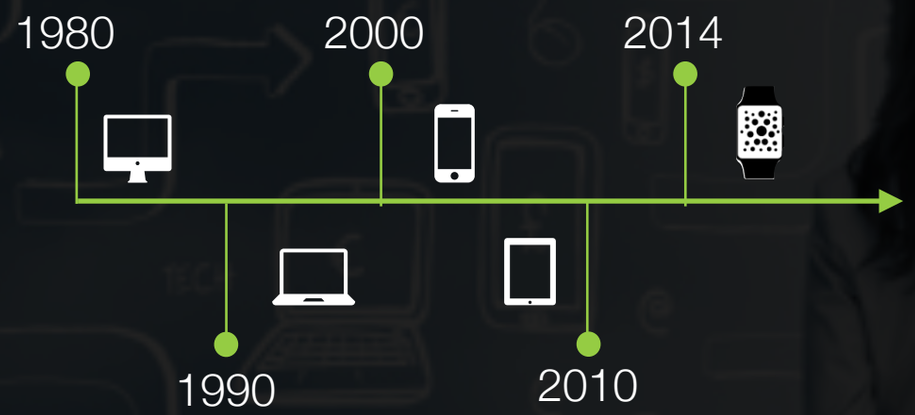
Everything is Connected

2 Questions

Internet is all about Human Experience not Bits and Bytes!

What Human Experience will be defined by an IoT enabled World?


1980
2000
2014
1990
2010

If everything is connected why would you need a device?

Zero Interaction and Zero UI

WiFi is the most Pervasive Sensor Network. Its available literally everywhere.

Internet of Things @ Bell Labs

To what extent can we leverage existing wireless network as a platform for connected objects?

To what extent can we leverage existing wireless network to understand human behaviour?

People-Content Interaction

People-Object Interaction

People-People Interaction

Wireless network is the key fabric for designing connected human experiences

People-Content Interaction

People-Object Interaction

People-People Interaction

”Energy Efficient Scheduling for Mobile Push Notifications”. MobiQuitous 2015


Verizon
90%
10:43
Wednesday, October 2
TED
TED 13m ago
New TED Talk: Data scientist Amy Webb didn't leave love up to chance. She reverse-engineered her online dating profile.
slide to view
Push Notifications

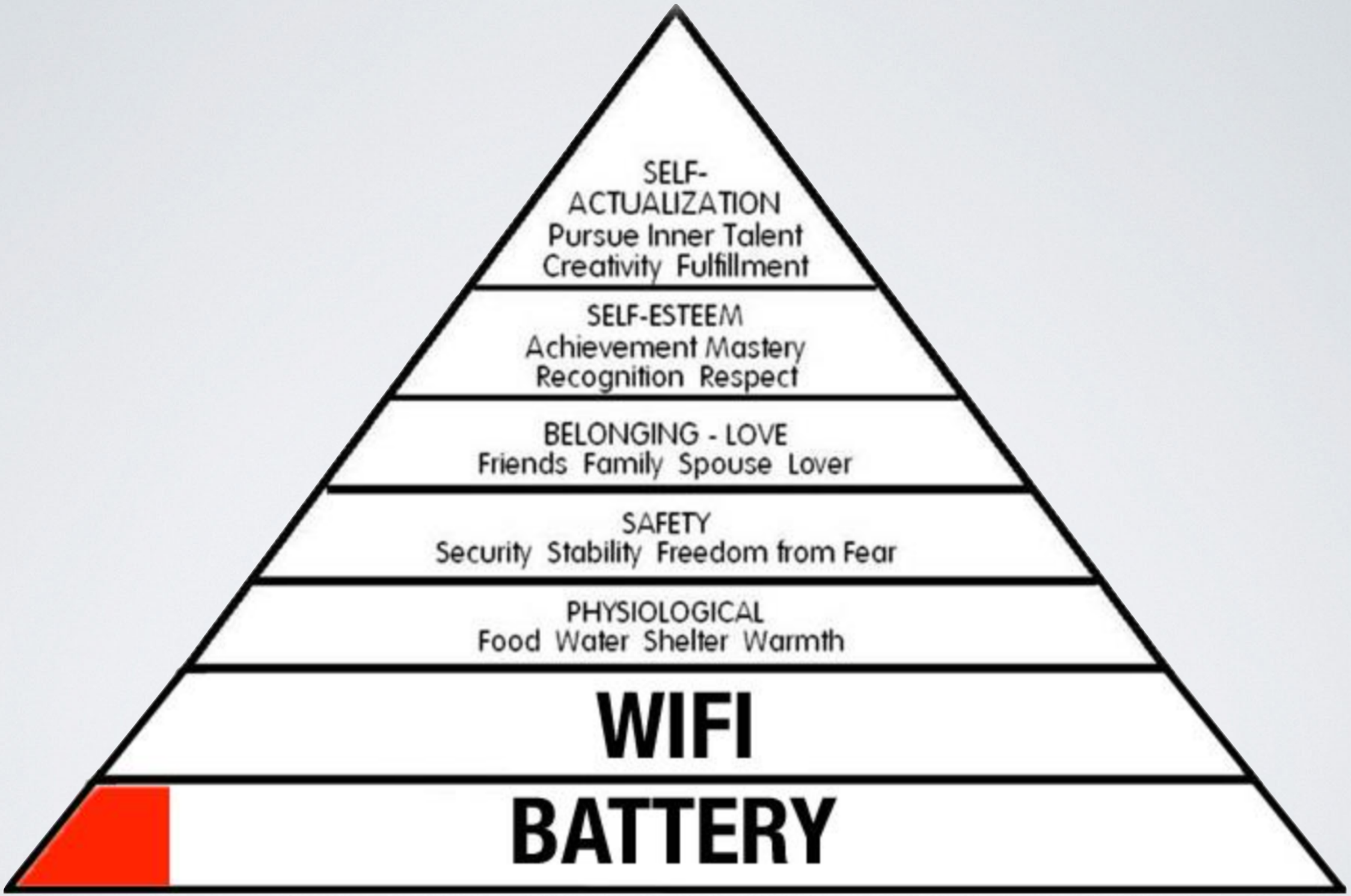
14:38

WHATSAPP

sophie charara:
ARE YOU KID-
DING ME?

Dismiss

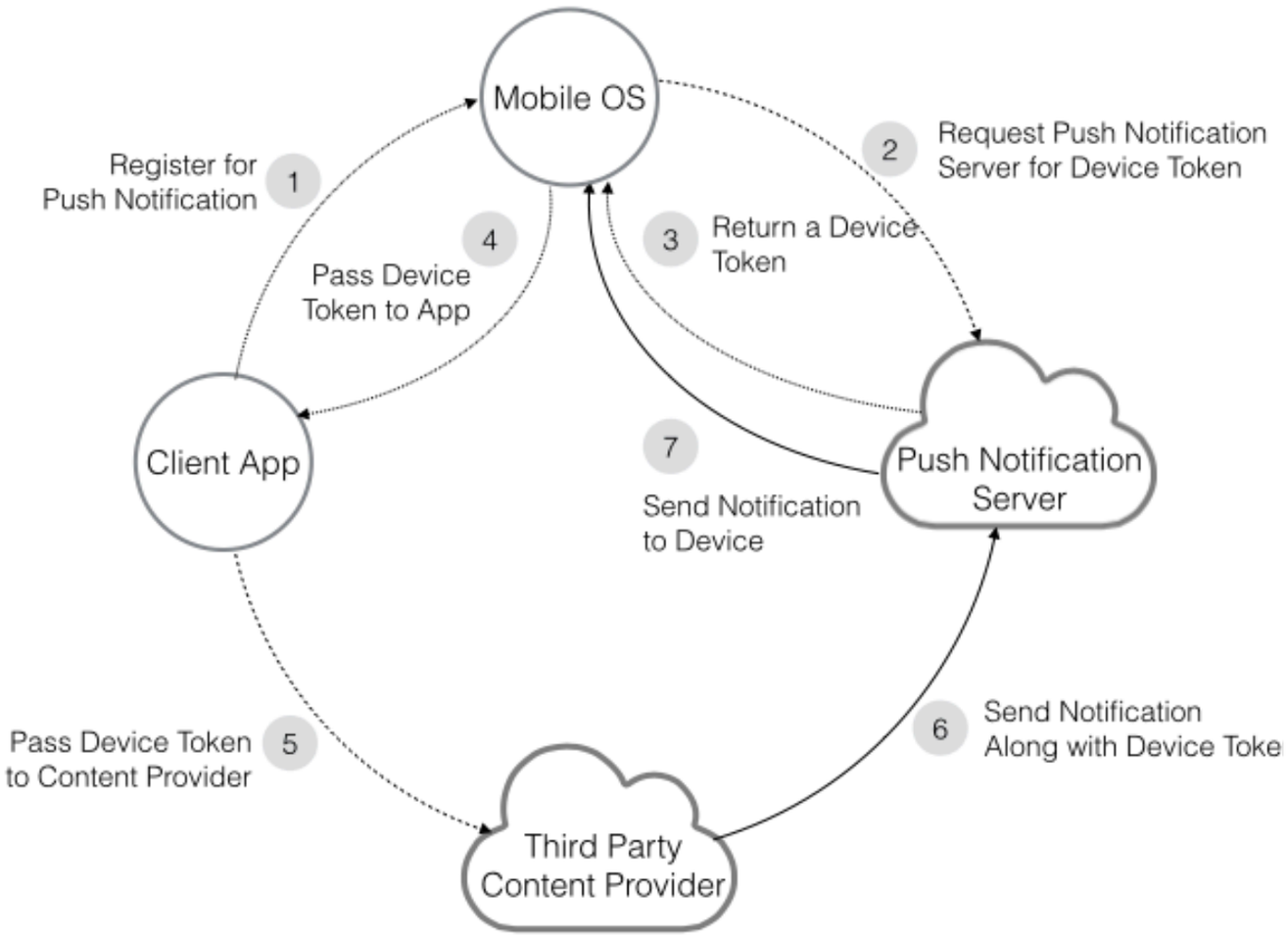

Clear All

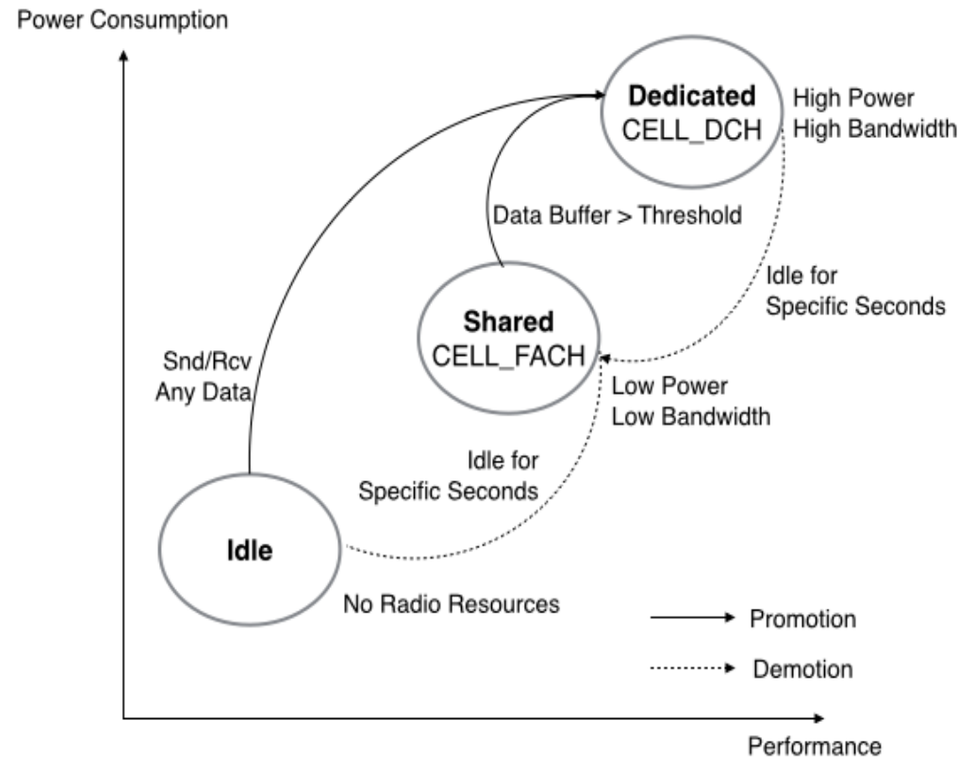

SELF-
ACTUALIZATION
Pursue Inner Talent
Creativity Fulfillment
SELF-ESTEEM
Achievement Mastery
Recognition Respect
BELONGING - LOVE
Friends Family Spouse Lover
SAFETY
Security Stability Freedom from Fear
PHYSIOLOGICAL
Food Water Shelter Warmth
WIFI
BATTERY

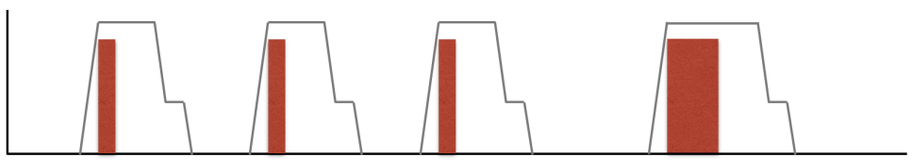
Push Notification and RRC State Machine

A mobile device is in the CELL_DCH state for a specific time period (which is called tail time) without any or small data transmission after a data session, and this tail time corresponds to

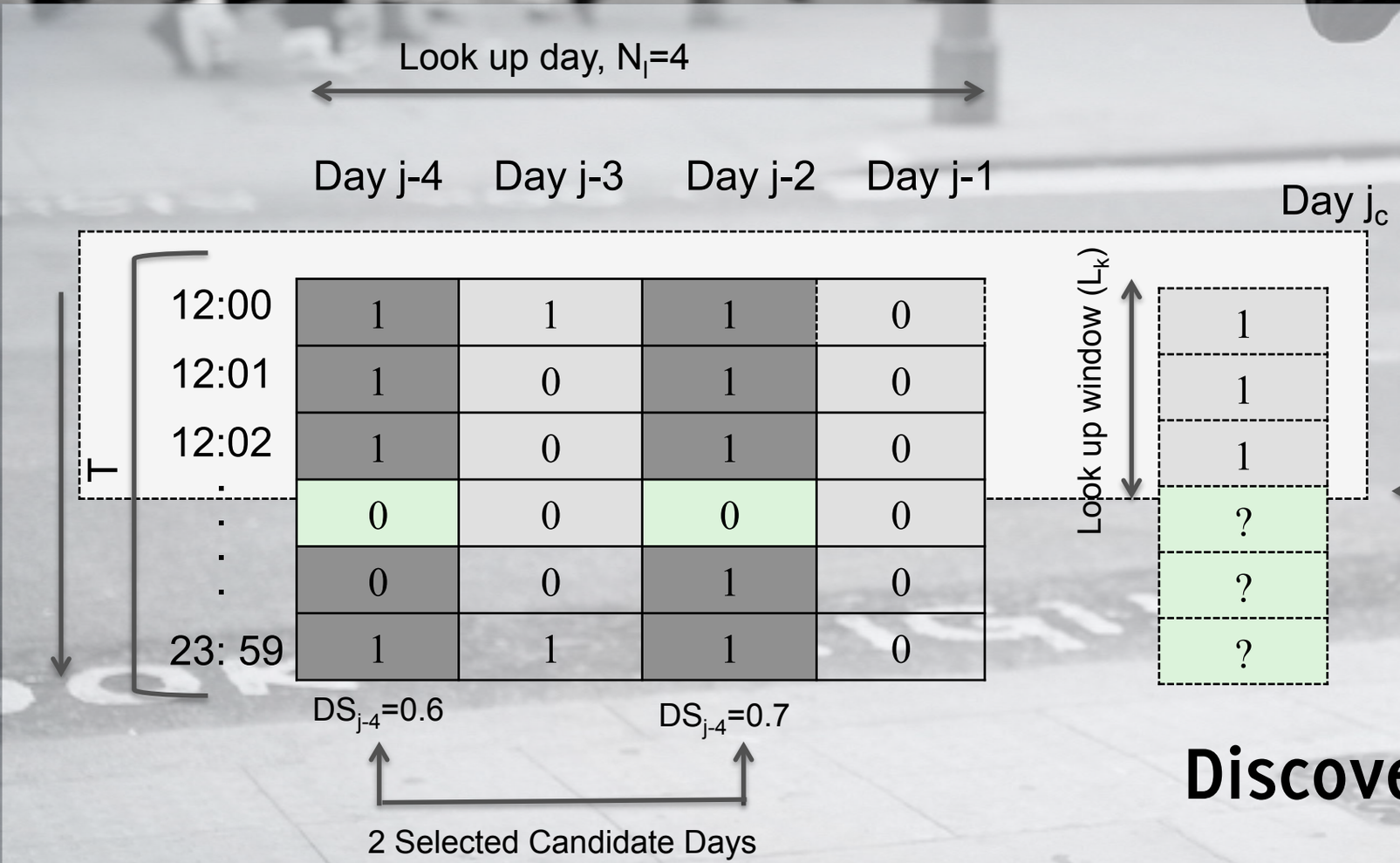
60% of the total energy consumed by UE.





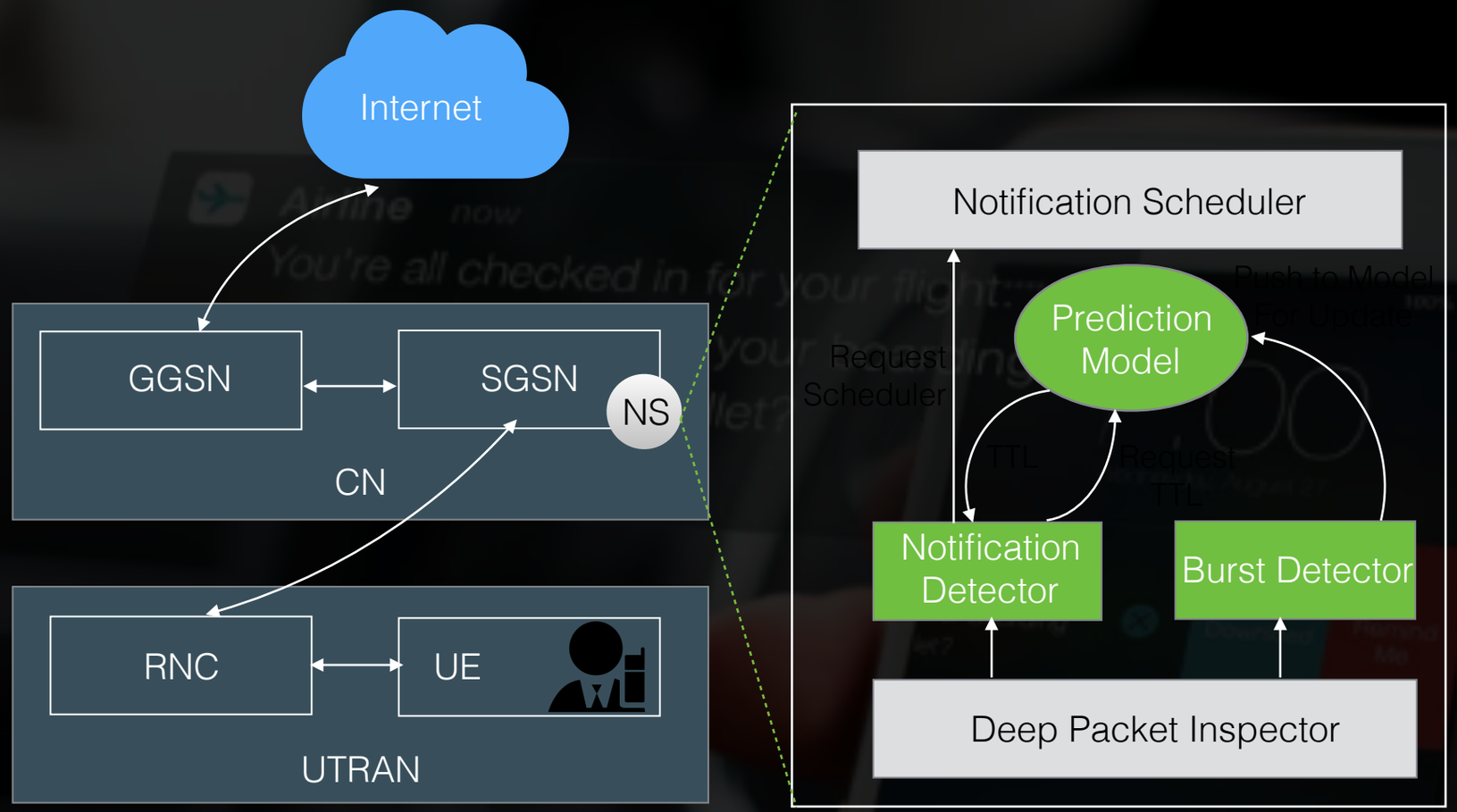


Bringing the Network into the Story



Over **75%** of network activity can be predicted with accuracy of over **80%**

Discovering the Human Routine



Average latency is 157 seconds.

±15% energy can be saved by buffering notifications.

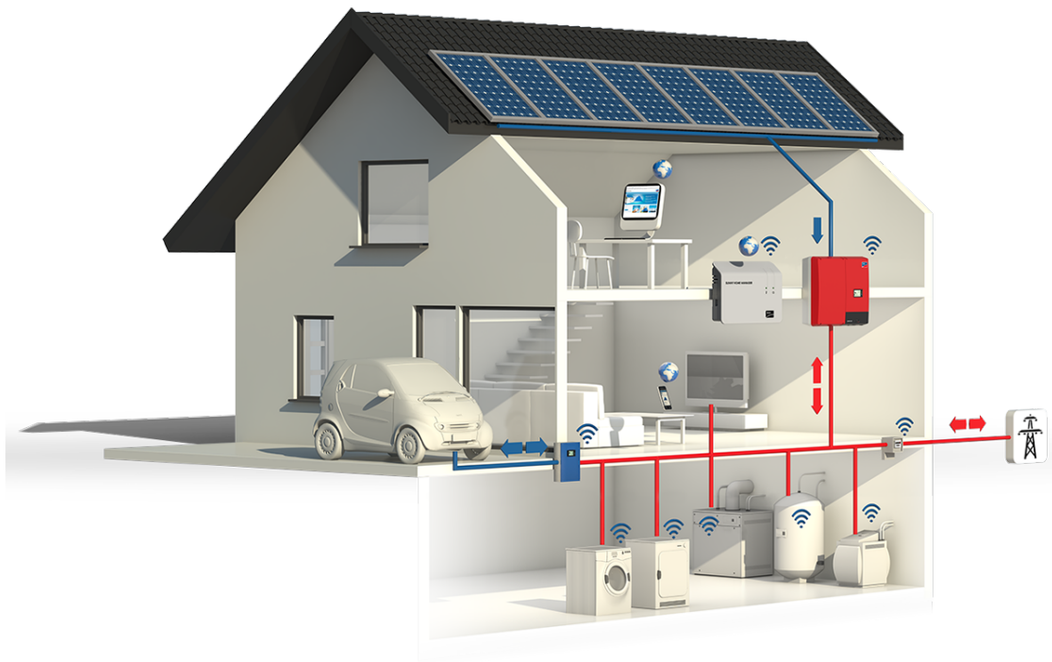
People-Content
Interaction

People-Object
Interaction

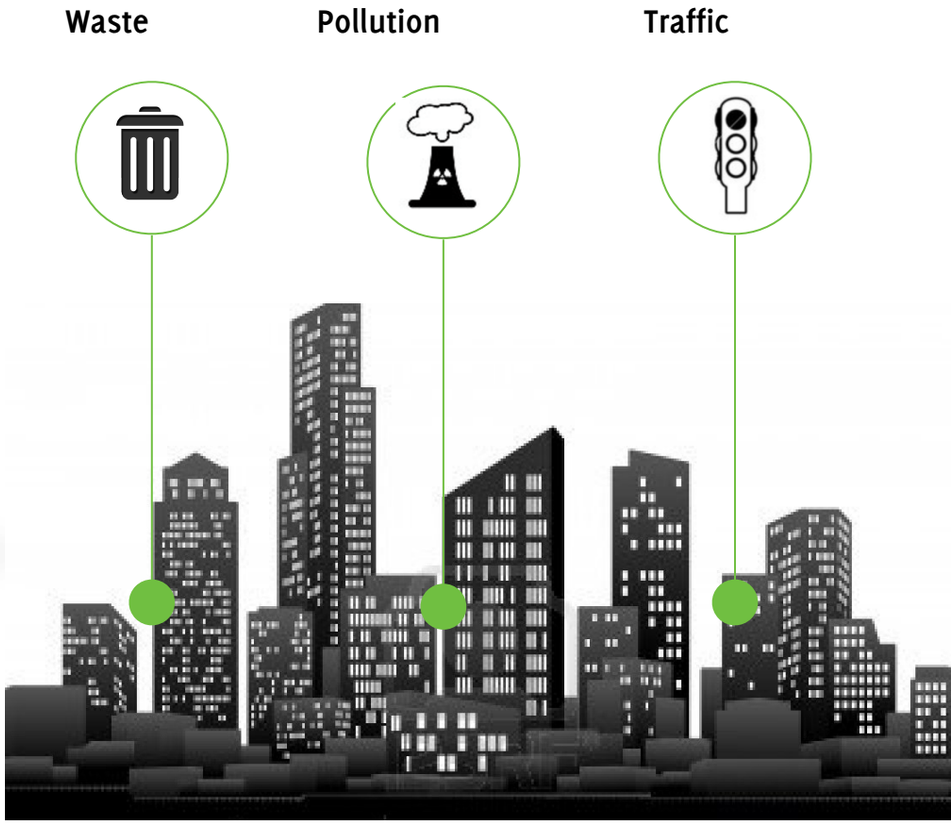
People-People
Interaction

”Sensing WiFi Network for Personal IoT Analytics”. IoT 2015

Quantified Self



Quantified Home



Quantified City

Search for physical objects' location and state is one of the basic services that provides foundation for many applications.

Dedicated Sensing Infrastructure (ZigBee, RFID, Mote, etc.)

- High deployment and management costs

Bluetooth Discovery with Smart Phone

- Search range is limited to the smart phones' proximity

What we learnt in the past

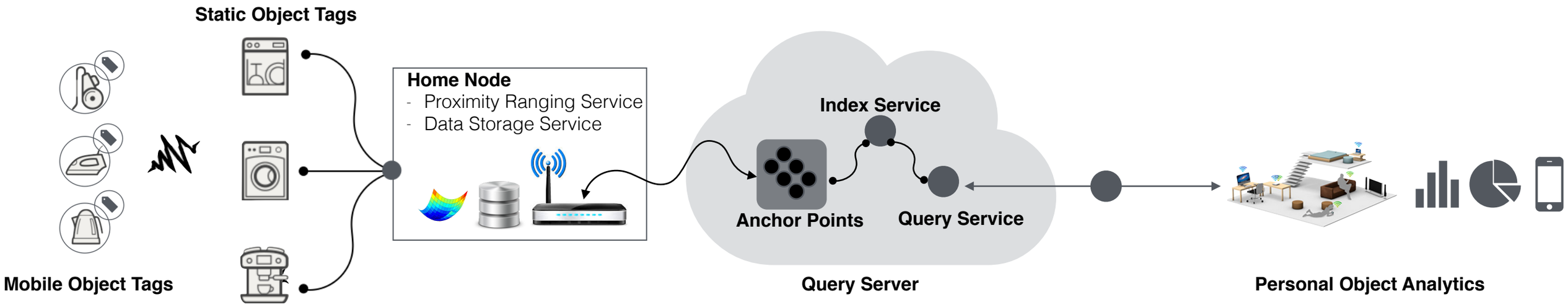
Research Objective

Can WiFi network be used as a platform for personal IoT analytics?

Premise

Connected objects’ movement data extracted from WiFi network signals carries vital information to model their spatio-temporal usage pattern

System Architecture



System Components

Object Tags

Attached to physical objects and emit the location and state-of-use of the physical objects.

Home Node

Hosted in the residential home gateways, provide proximity ranging service, and stores objects data.

Query Server

Hosted in the cloud, maintains persistent connection with home node and provides query interface to personal analytics applications.

IoT Analytics

Prototype Personal IoT Analytics Application

“Quantify the Spatio-Temporal Usage of Personal Object”

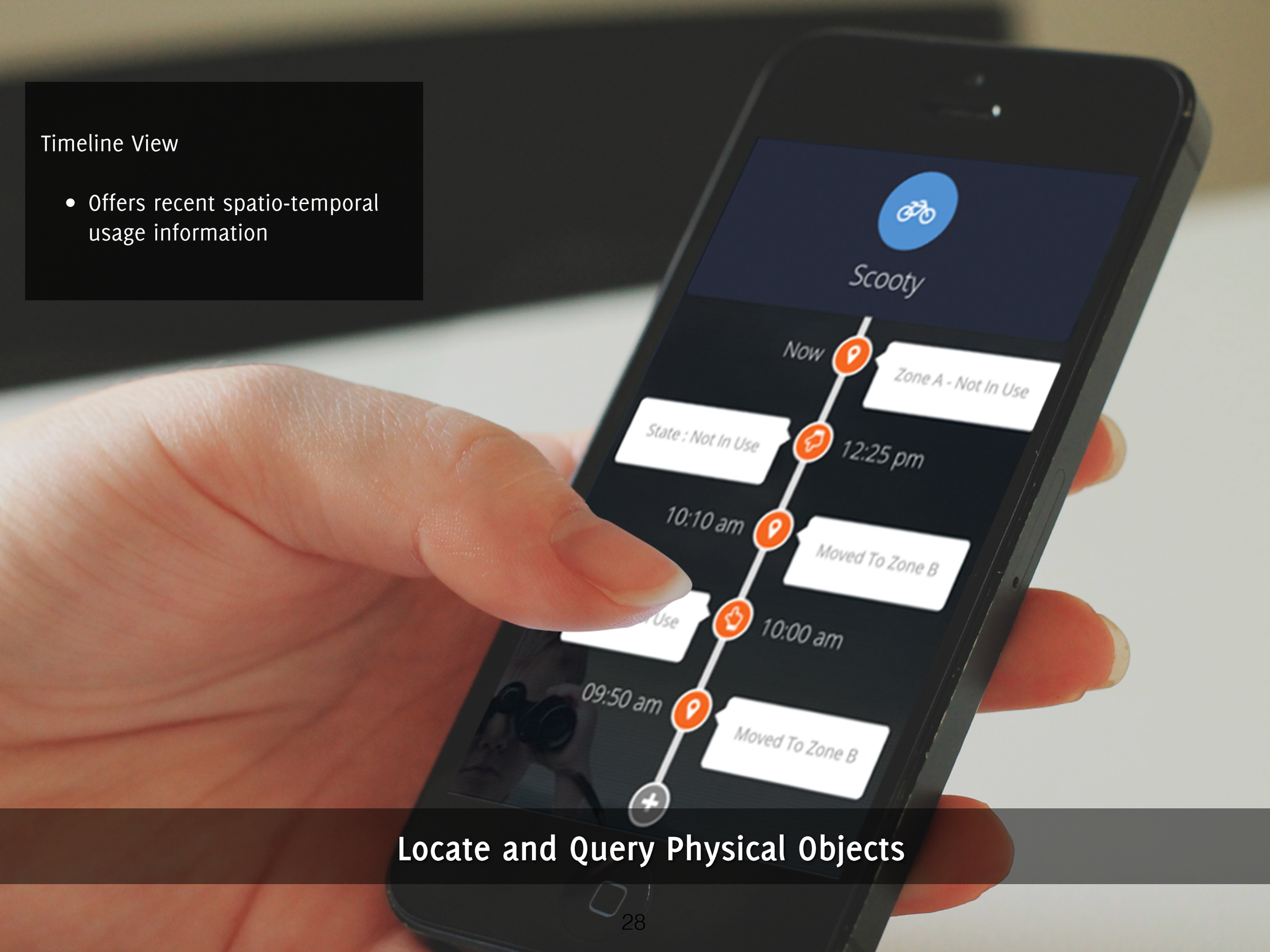
Dashboard

- Shows realtime usage status (pointer up or down)
- Offers search capability

Things Dashboard

Timeline View

- Offers recent spatio-temporal usage information



Locate and Query Physical Objects

Insight View

- Offers aggregated spatio-temporal usage information

Realtime Insights on Spatio-Temporal Usage

You Own Your Data, You Sell Your Data

- Our cloudlet based design scheme coupled with WiFi management frame based data transport offer implicit privacy and data protection as Data remains in the home gateway and this provides users with the control of their own data to do whatever they want to do with them – delete, sell or share.

- An advantage of these design schemes is that, it opens up opportunity for wilful monetisation of personal data

Gerd Kortuem and Fahim Kawsar **"Market-based User Innovation for the Internet of Things"**; Internet of Things 2010 Conference

Afra Mashhadi, Fahim Kawsar, and Utku Acer
“Human Data Interaction in IoT: The Ownership Aspect;". The IEEE World Forum on Internet of Things 2014

People-Content Interaction

People-Object Interaction

People-People Interaction

”Tiny Habits in the Giant Enterprise: Understanding the Dynamics of a Quantified Workplace”. UbiComp 2015

”Detecting Human Encounters from WiFi Radio Signals”. MUM 2015

Quantified Enterprise

Active Badge - Xerox | Cambridge U

That Privacy Thingy!

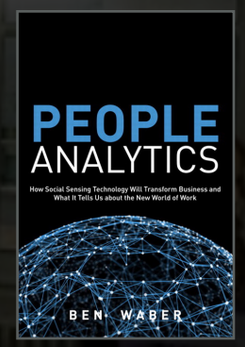

YouTube
Bē
Fil Dunsky
http://be.net/dunsky

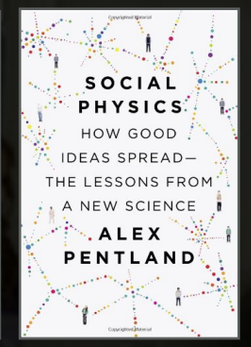
Happiness Badge - Hitachi

Sociometer Badge - MIT

Spontaneous Interactions

Key to Flow of Ideas





A third of team performance can be predicted merely by the number of **Face to Face** exchanges among team members.

The “data signature” of natural leaders can be discovered.

Daily Productivity and Creativity can be rightly assessed.


the
LinkedIn
factor

“Only **4%** of large companies can make meaningful predictions about their workforces, while **90%** can accurately predict business metrics such as budgets, financial results, and expenses”

- Bersin Research

Quantified Enterprise

Understand and quantify how people interact and work together in the real enterprise for personal, group and larger organisation efficiency.

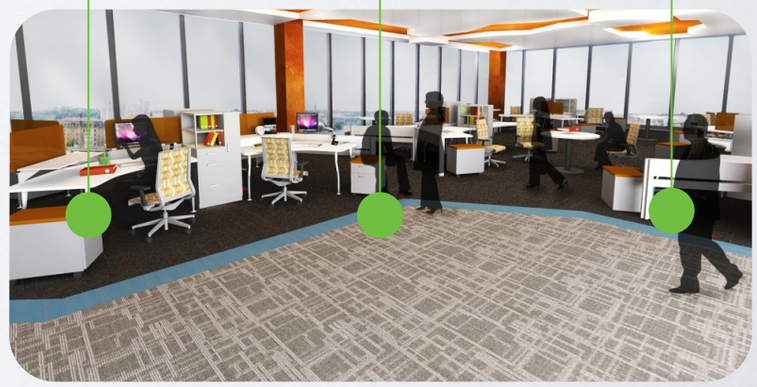
Quantified Self

Quantified Team

People Analytics

Productivity Management

Space Management



Quantified Enterprise

Implications

For Building Managers

- Predictive Maintenance
- Better Space Arrangement & Management
- Personalised Space Recommendation
- Better Resource Management

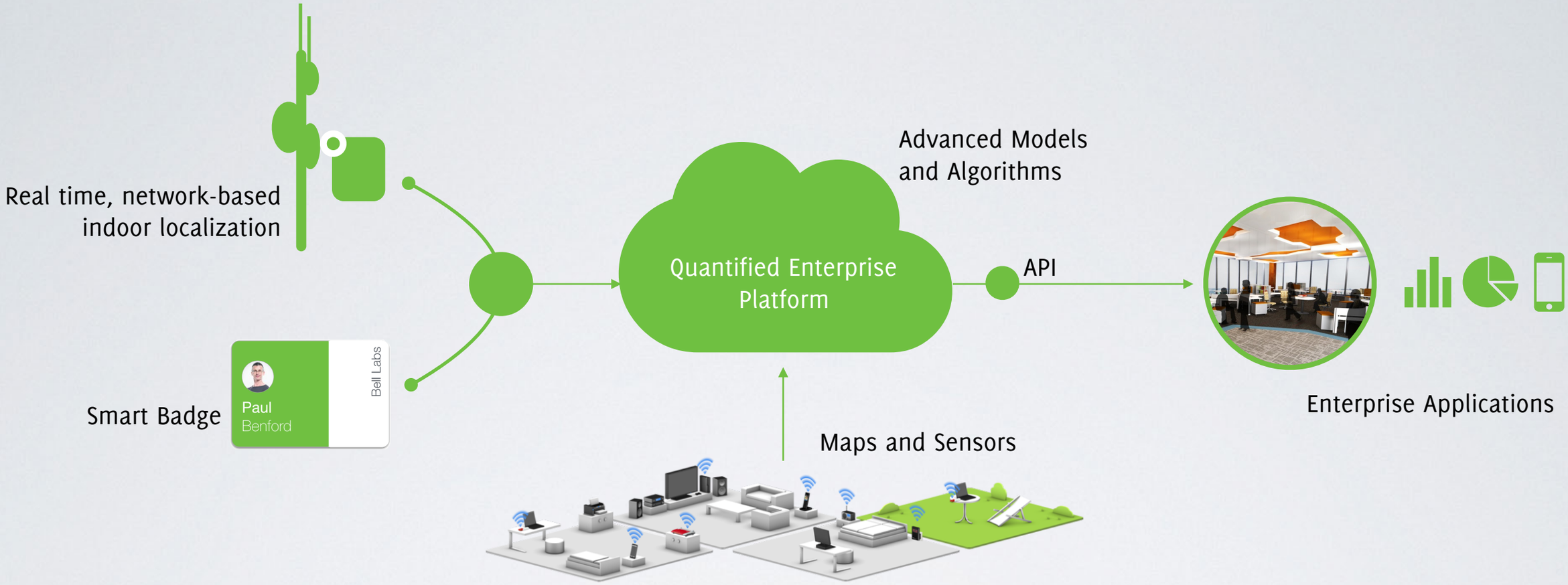
For Employers

- Quantifying Collaboration
- Discover Emerging Leaders
- Build High Performance Team
- Develop Empathic Relationship

For Employees

- Personal Interaction Reflection
- Personal Network Scale and Diversity
- Personal Time and Activity Management
- Personal Connection Extension

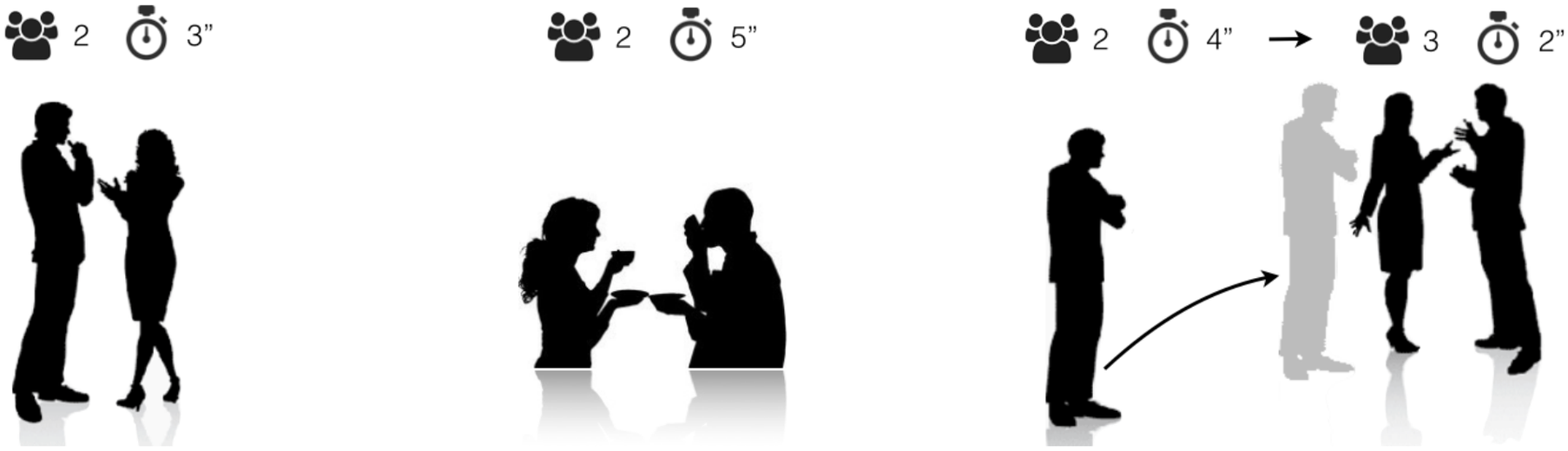
A Network and Small Data Driven Solution



50x reduction in deployment and management cost

30x reduction in energy expenditure of mobile devices

Location to Face to Face Interaction



A network-centric architecture that captures existing radio signals (WiFi probes) from the user’s device.

Radio Signal Capturing

Co-location detection based on similarity of wireless channel propagation characteristics.

Copresence Detection

Interaction Inference

An empirically defined model grounded upon sociology theories, by leveraging the size and duration of the encounter.

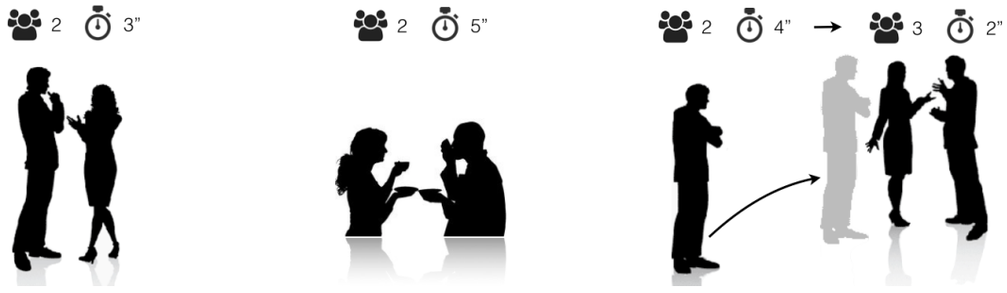
60% of Encounters Detected

90% Accuracy (Precision)

Behaviour Modelling

Extracting high order behavioural traits

Location -› Face to Face Interaction



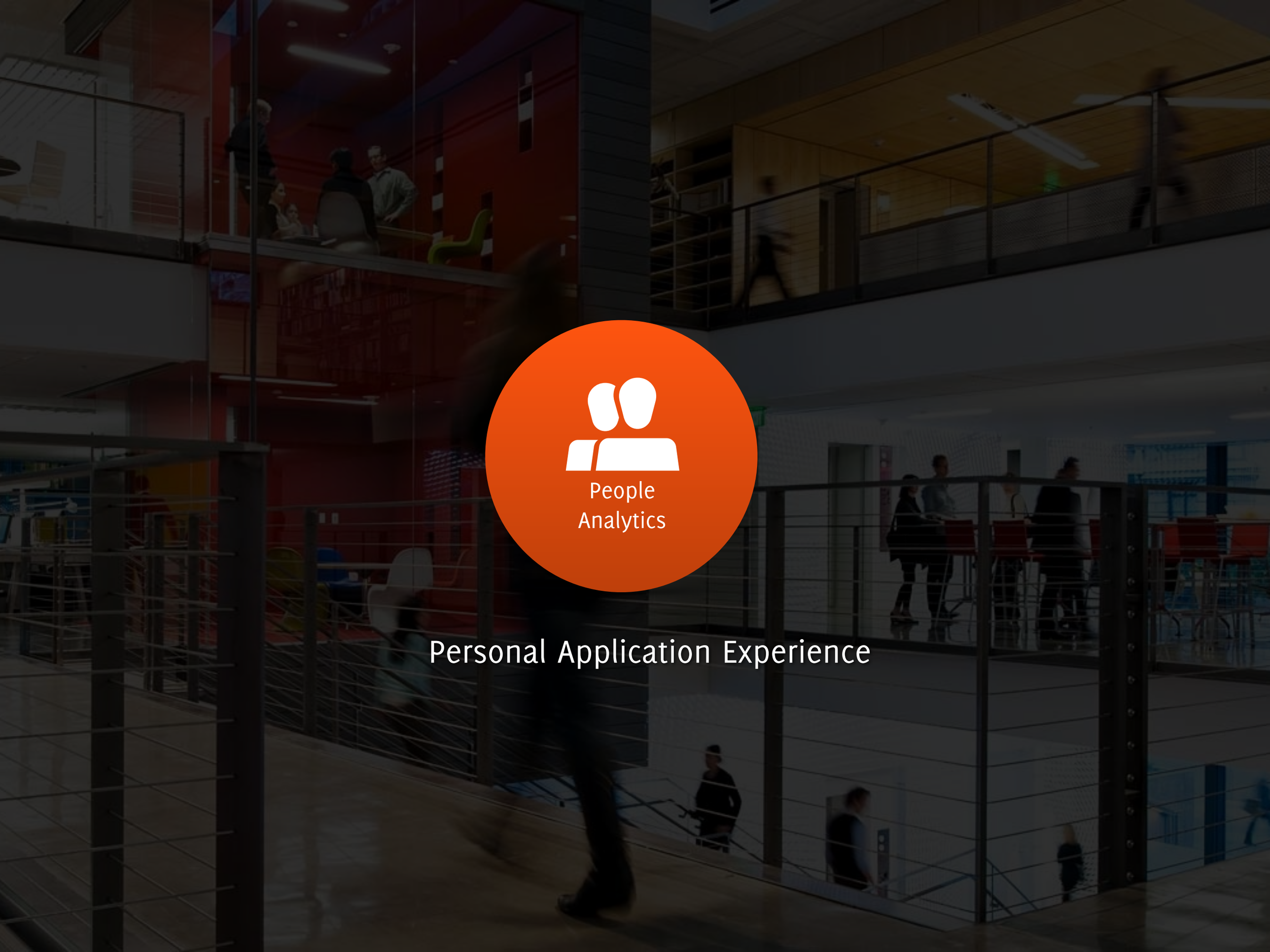
This has been used to build connectivity graph and show collaboration intensity in the application.

Location -› Personality

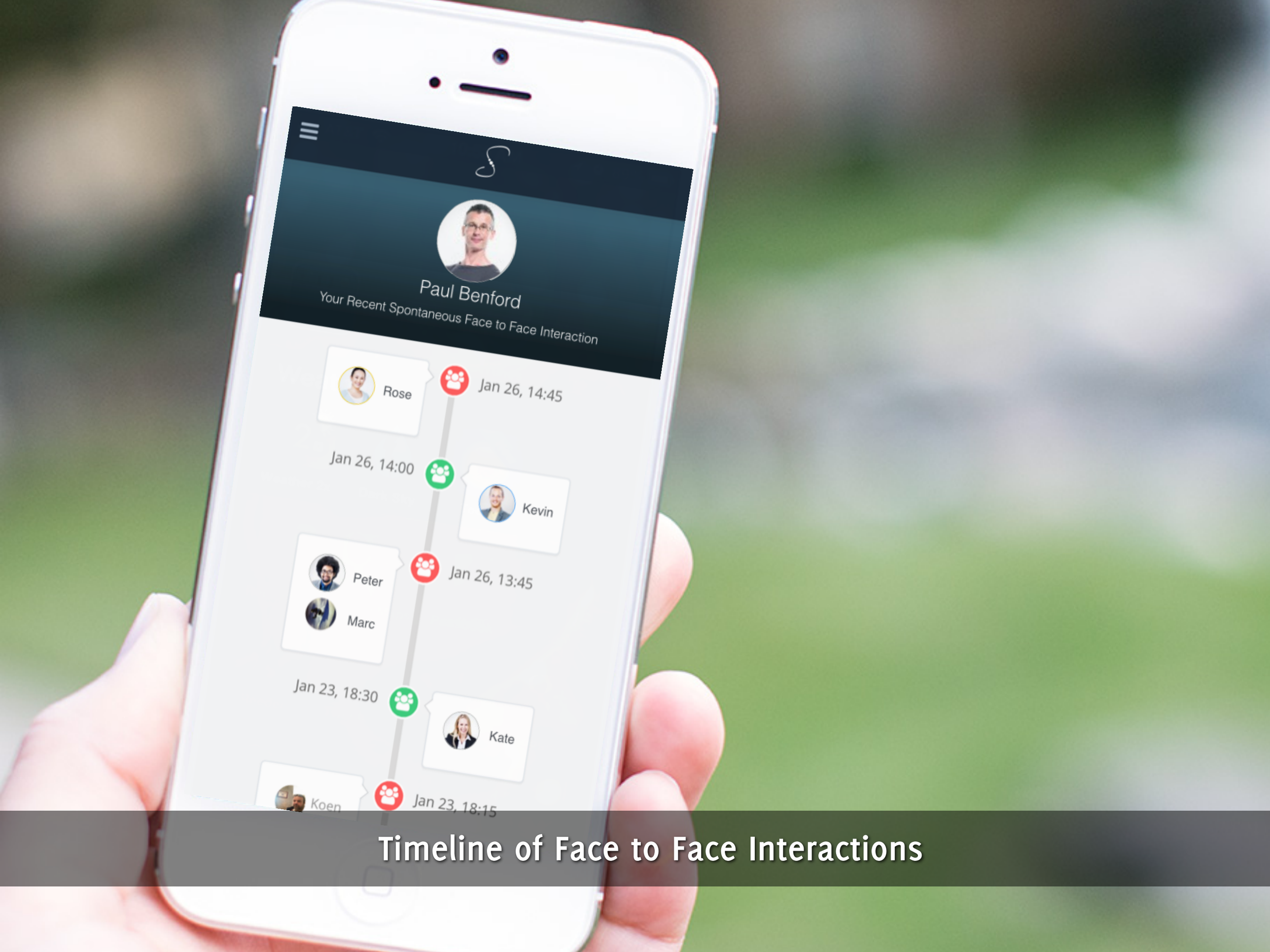
F2F Encounter Diversity, Number, Frequency, regularity and Spatial Behaviour are used to extract Big Five Personality Traits

Location -› Happiness

Spatial Behaviour and Movement Trajectory are used to estimate Physical Activeness and then map to mental wellbeing (baseline Happiness Index Survey)


People
Analytics
Personal Application Experience

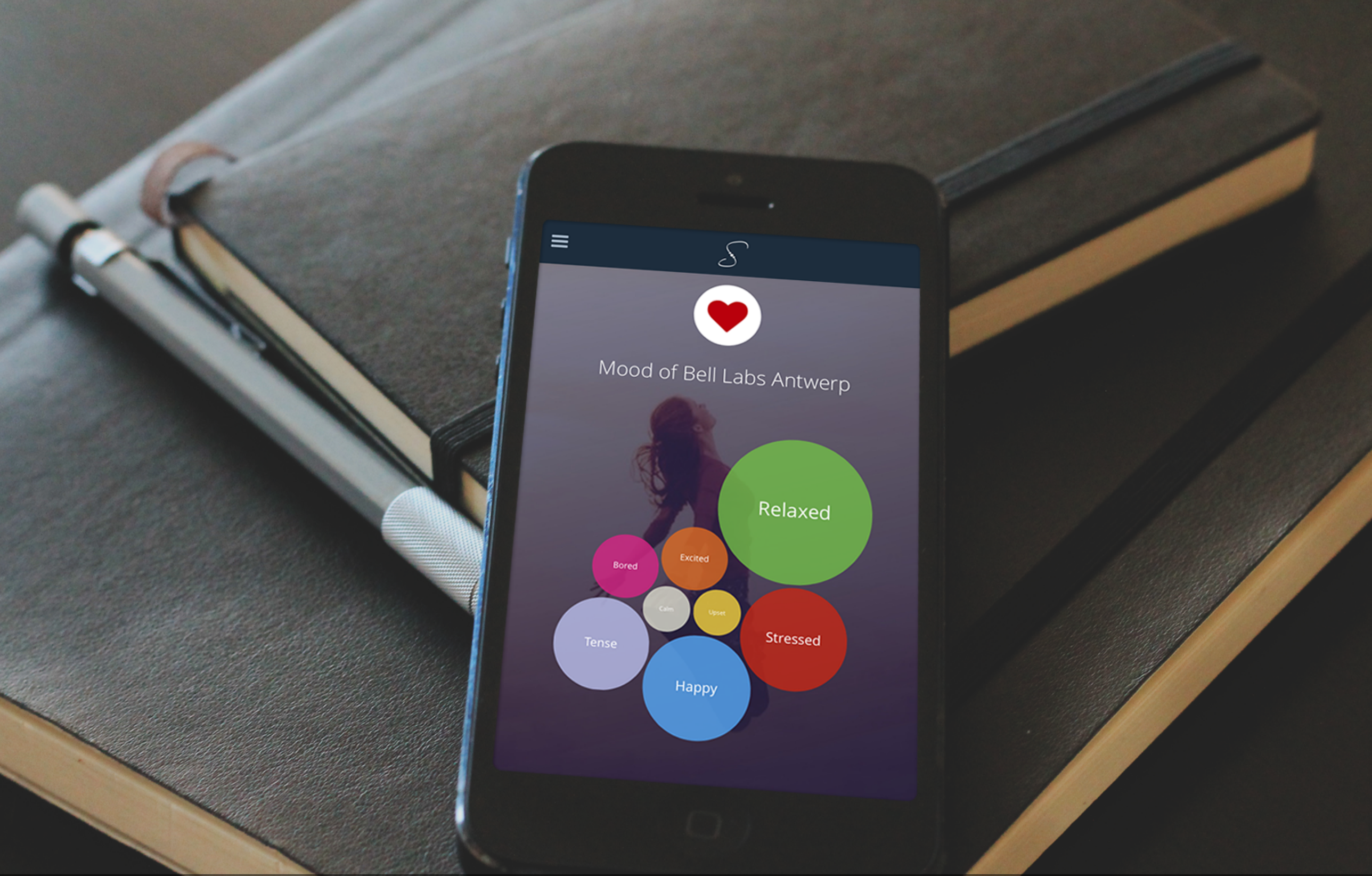
Self Quantification @ Workspace



Timeline of Face to Face Interactions

Realtime Recommendation to New Contacts

Locating Colleagues and Empty Rooms at Realtime



Happiness Map of the Workspace

Playful Visualisation of the Workplace Mood

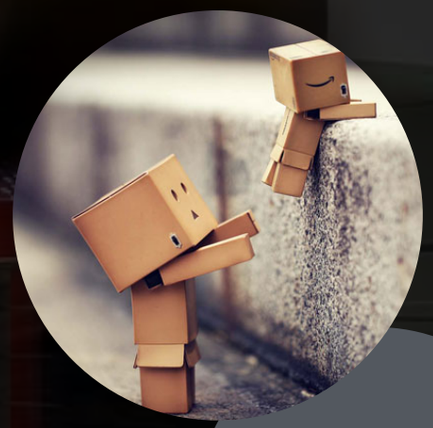
Collaboration Uncovered

Insights from Quantified Bell Labs (Dublin and Antwerp) Workplaces

3 Secrets Revealed

Its all about Relationship

Key to Engagement is the visualisation of the relationship structure



Subtle Hints

Users awareness of their collaboration nature is crucial, however presentation needs to subtle but meaningful

Recommend Opportunities

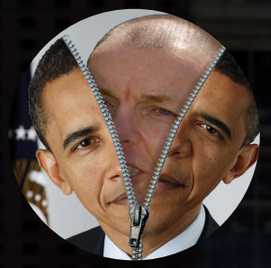
Users are willing to compromise their privacy when the value is higher. Recommendations of right opportunities are key to create that value

Credit goes to ...

Claudio Forlivesi

Utku Acer

Geert Vanderhulst



Marc Van Den Broeck

Marc Godon

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Thank You