Internet of Things

Improving the Digital World
May 2015

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Internet of Things

1. Connected Living
2. M2M
3. Harmony

1. Connected Living

A. Connected Living markets - Opportunities by vertical

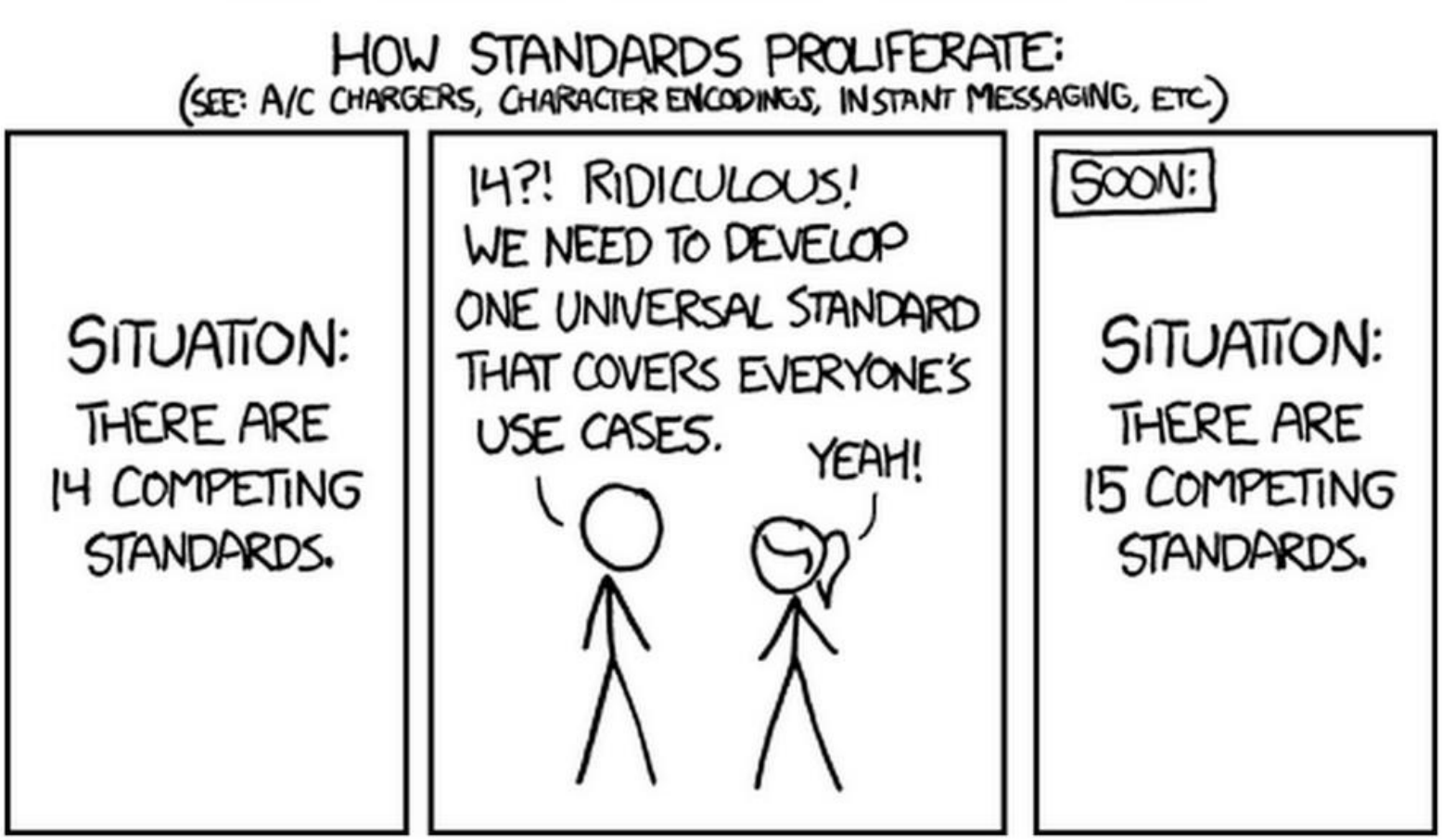
Definition

- Connected Living refers to the digital economy in which computing applications and services will impact every aspect of consumer lives in the home, work and city environments.
- Connected Living is enabled by new trends in…
  - Low cost sensors
  - Cloud computing
  - Mobility
  - Big Data

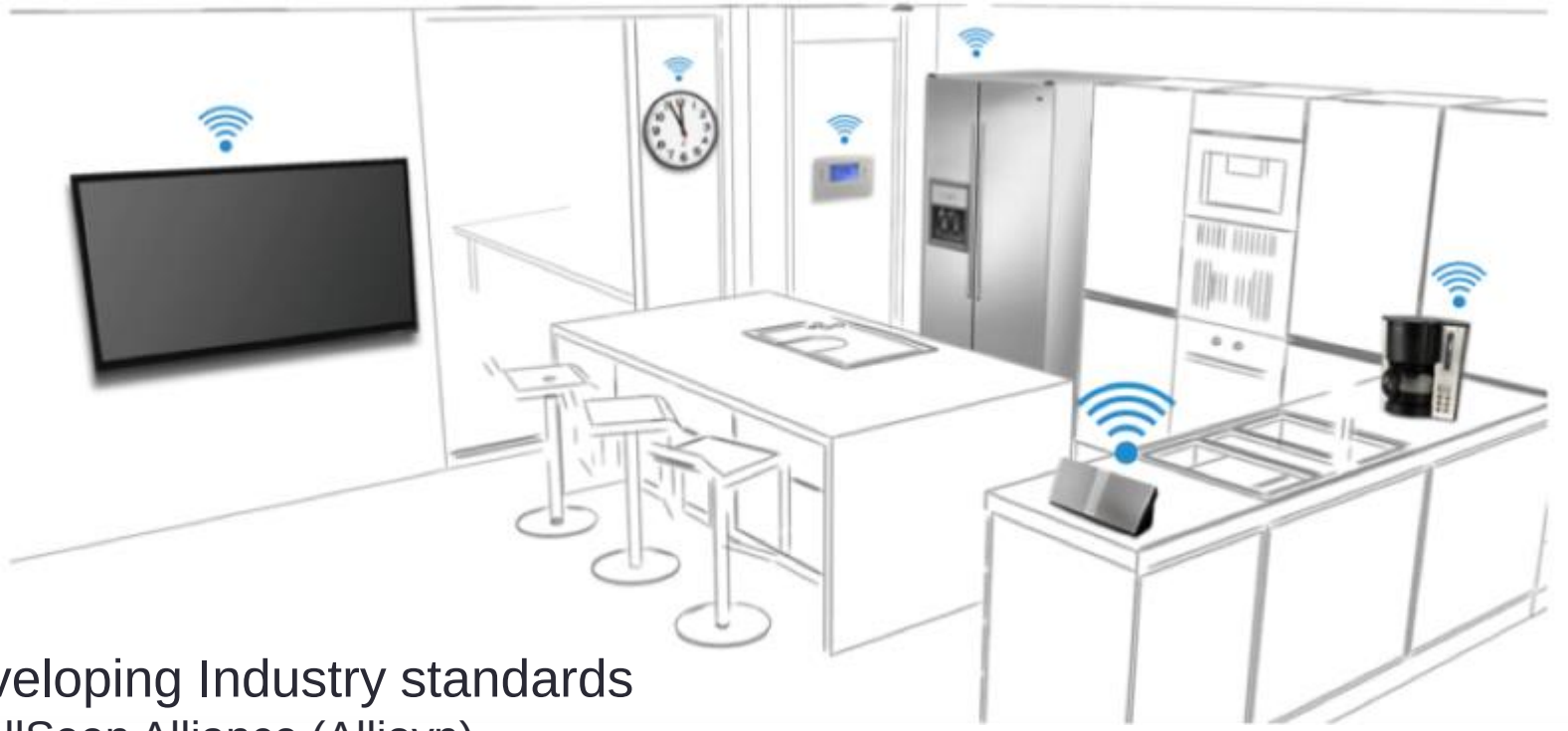
10 key drivers for market growth

- Connected Car
  - infotainment, apps, navigation, telematics
- Electric vehicle charging
  - payment, location, booking charge points
- Clinical remote monitoring
  - cost savings, pre-emptive action
- Security
- Assisted living
  - independence for the old and infirmed
- Pay as you drive insurance
  - flexible time, usage, behaviour models
- Car hire, share, lease
- Traffic management
  - toll revenue, road and congestion charging, parking
- Smart metering
- Building automation

Source: Machina Research October 2013


HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)
SITUATION: THERE ARE 14 COMPETING STANDARDS.
14?! RIDICULOUS! WE NEED TO DEVELOP ONE UNIVERSAL STANDARD THAT COVERS EVERYONE'S USE CASES.
YEAH!
SOON:
SITUATION: THERE ARE 15 COMPETING STANDARDS.

Connected Home



- Developing Industry standards
  - AllSeen Alliance (Alljoyn)
  - ZigBee Alliance
  - Z-Wave
  - Thread
  - OM2M
- Real-world testing is immature or non-existent

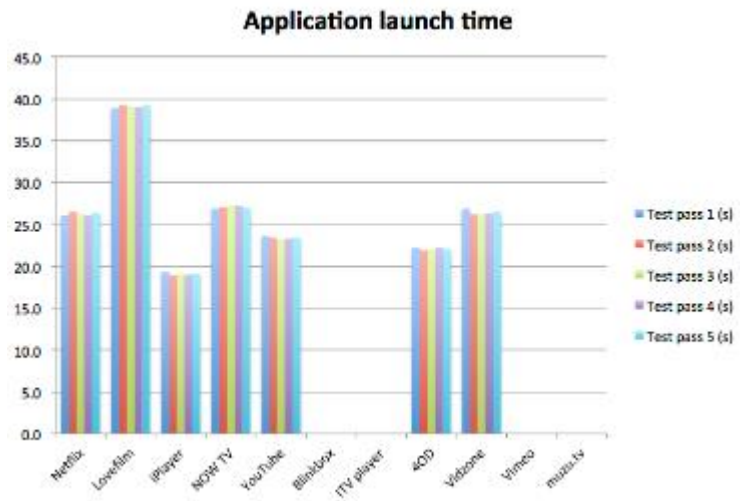
1. Connected Living

B. Case Studies

Case study: Digital TV (OTT)

- Localisation
  - User Interface (UI) audit to confirm brand guidelines are followed by OEMs or application developers
- Benchmarking
  - Application performance benchmarking to monitor end-user experience
- Remote test bench management
  - IOTAS manages in-country systems to allow debug and development remote from customer HQ
  - Available in IOTAS regional test centres (UK, Australia, Germany, France…)





Case study: Digital TV (OTT)

- IOTAS have a range of benchmark devices including:
  - Smart TVs
    - LG LM620T
    - Panasonic TX-L32E5B
    - Panasonic TX-L42ET60
    - Panasonic TX-L42ET60B
    - Panasonic TX-L42ET60E
    - Philips 32PFL3208T
    - Samsung Series 5 F5500 32
    - Samsung UE40ES5500
    - Sony KDL26EX553BU
    - Sony KDL32W656
  - Blu-ray Players
    - LG BP325
    - LG BP520
    - Panasonic DMP-BDT120EB
    - Samsung BD-E6100
    - Samsung E6500
    - Sony BDPS3100
  - STB
    - Philips HMP2000/05
    - Sony NSZ-GS7
    - Western Digital WDBGXT0000NBK

Case study: TalkTalk Super Router

TalkTalk Group

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Press releases | Key policy issues | Speeches and presentations | TalkTalk blog | Press contacts

TalkTalk supercharges Fibre broadband with new Super Router

23/05/2014

- TalkTalk Super Router offers Britain's fastest Wi-Fi technology
- Unbeatable Wi-Fi connection – smarter, with even better coverage
- Furthest signal reach in independent testing against BT, Sky, Virgin Media and EE

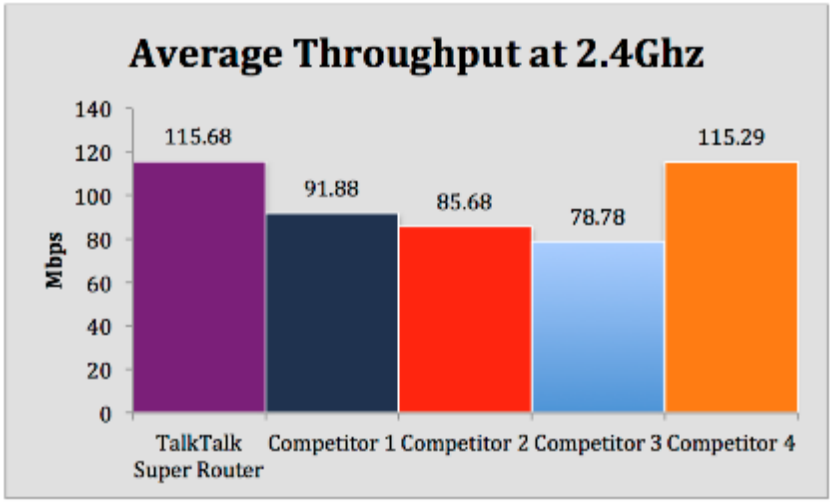
TalkTalk has today unveiled its best ever router, packing the UK's fastest, next generation Wi-Fi tech optimised for TV and designed to provide further coverage throughout the home.

It will be included in all new TalkTalk Superpowered Fibre Broadband packages from 24 May and wi to upgrade to Fibre.

In independent testing, the Super Router's Wi-Fi range was unbeaten against flagship routers from superfast 802.11ac Wi-Fi technology, which connects devices up to three times faster and offers a s

The Super Router is dual-band, so it sends a signal on two frequencies at the same time, which red interference. It also focuses the signal in the direction customers connect from to provide TalkTalk's

The Super Router is a one-box solution and doesn't require a BT Openreach modem, which means To simplify things further, mobile devices can be connected to the Wi-Fi network at a push of a butto password.



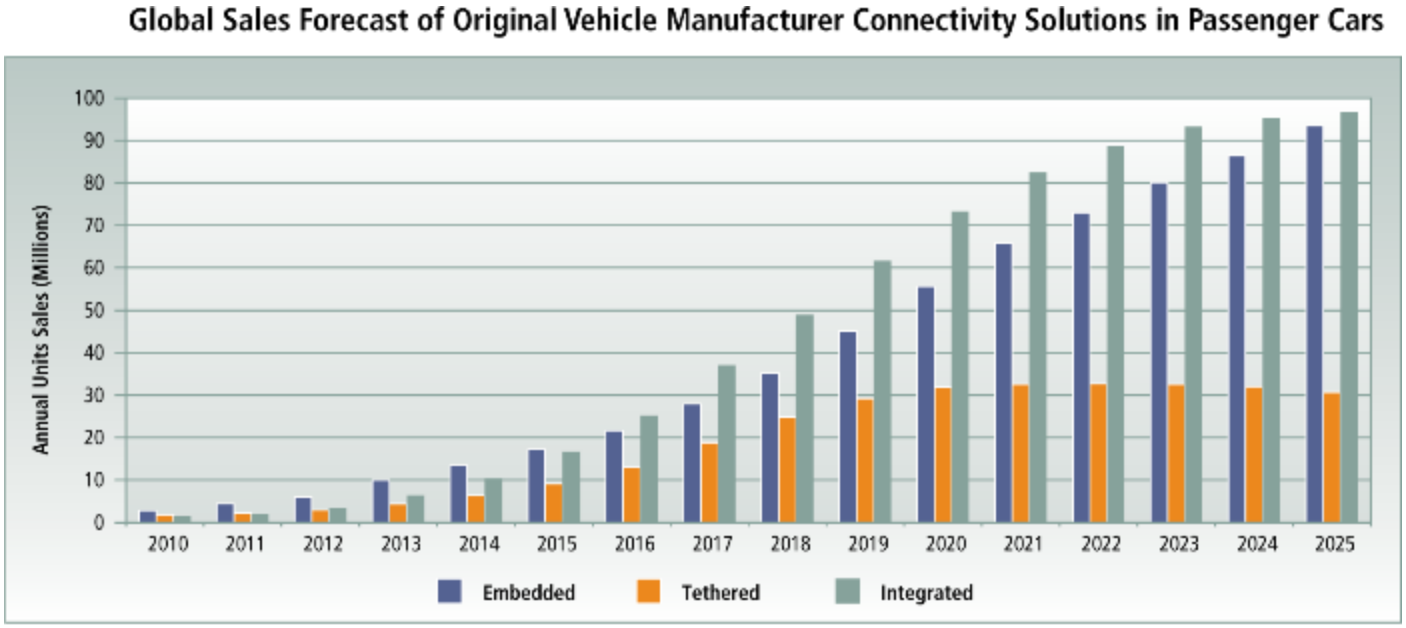
"The (Super Router) provided the best data throughput performance of all routers at 2.4Ghz operating frequencies." *(Source: IOTAS)*

Case study: Small Cell testing

- Functional testing
  - Voice call - Default CODEC, call success rate
  - Supplementary services
  - Messaging – SMS, MMS
  - Data throughput
- Router interoperability
  - Configuration steps required
  - Data consumption for typical call (MB per hour) and idle
  - Performance with varying line conditions – limited throughput, increasing round-trip time
- Quality of Experience
  - Notifications
  - Measure time-to-connect isn't adversely affected
  - Test maximum number of cellular users
  - In-building coverage



Automotive



Source: GSMA / SBD 2025: Every Car Connected[1]

- Network operator interoperability testing for *embedded SIM*
- Device interoperability for *tethered connection* to popular handsets
- KPI and performance measurement for *integrated devices* to maintain end-user satisfaction and reduce in-field support costs

1. Connected Living

C. Wi-Fi interoperability testing - Extending the range of end-user environments

Background

- Wi-Fi Alliance (ASD) testing to IEEE802.11
  - Relatively small number of APs/controllers tested
  - Default configurations only
  - Lab based testing only
- IOTAS currently works with a partner lab to perform Wi-Fi Alliance ASD pre-compliance and formal testing
- 3rd party test tools (silicon manufacturers) may provide scope for additional IOP test cases
- Greater diversity available
  - Client OS (Windows, Android, iOS, Linux)
  - Increased selection of WLAN controllers and APs
  - Traffic types: HTTP, SIP calls, MPEG-2 video, file sharing

1. Connected Living

D. Interoperability testing UK consumer and business routers

Test scope

- Device level testing to measure the following KPIs
  - AP discovery time
  - On-device SSID auto-selection/forget modes
  - Time to served DHCP address
  - Data performance (throughput/ping)
  - Hidden SSID selection
- Authentication protocols
  - Open
  - WEP
  - WPA- PSK
  - Wi-Fi Protected Setup (pushbutton and PIN)
- VPN pass-through
- Reported RSSI benchmarking

Access point selection

- ISP supplied routers
  - BT HomeHub 5
  - EE Bright Box 2
  - Sky Hub (SR102)
  - TalkTalk Super Router (HG635)
- Publically available routers
  - Apple Airport Extreme Base Station (ME918LL/A)
  - Asus RT-AC66U
  - Linksys WRT54GL
  - Ubiquiti UniFi Long Range

1. Connected Living

E. Interoperability testing UK public ISPs

Test scope

- Device level testing to prove the following KPIs
- Authentication methods
  - None
  - Closed portal
  - Cookie based
  - IP based
- Quality of Experience (QoE) measurements
  - Data performance (throughput, ping)
  - Video conferencing (Skype)
  - Large file download (jpg)
  - VPN performance

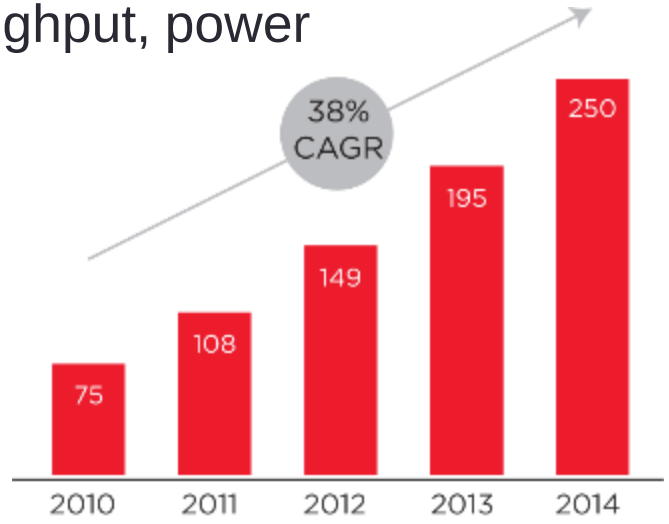
ISP selection

- The Cloud
  - McDonalds
  - Weatherspoons
  - Caffe Nero
  - Network Rail
- BT Openzone
  - Starbucks
  - FON
- O2 WiFi
  - Subway
  - Costa Coffee

2. M2M

M2M

- IOTAS is already supporting M2M manufacturers through device certification
- Module level confidence testing to de-risk commercial launch in the following areas…
  - KPI measurements including data throughput, power consumption
  - network operator pre-ranging test
  - interoperability testing for SIM card
  - RAN infrastructure testing



Global M2M connections (million)
Source: GSMA Intelligence

M2M



PRESS RELEASE | June 18, 2014, 9:05 a.m. ET

Telit and IOTAS achieve first M2M product certification through the Global Certification Forum's new class of Associate Manufacturer membership

New GCF approval process reduces time-to-market and overall costs for M2M device manufacturers to prove interoperability and reliability on live networks worldwide

LONDON--(BUSINESS WIRE)--June 18, 2014--

Telit Wireless Solutions, a global provider of high-quality machine-to-machine (M2M) solutions, products and services, and IOTAS, the UK's leading independent wireless field testing company, today announced that following the introduction of a new class of membership for device makers integrating embedded wireless modules, the Global Certification Forum (GCF) has certified the first product to successfully achieve the new certification. The product receiving this certification was based on Telit's GE864-QUAD V2 module. The new process allows a reduced scope of device testing for M2M device makers when using a wireless module already tested to the latest GCF specifications. The move leads to substantial savings, bringing M2M in reach of more business models which are today on the brink of viability for costs or time-to-market constraints.

"We complete GCF approval on our whole product range as a sign of our commitment to reliability, and to give our customers a better experience as they get their devices through the different stages of deployments in the telemetry and M2M market" said Carlos Perez, Executive Vice President Global Sales at Telit Wireless Solutions. "We welcomed this new certification class that allows our customers to achieve GCF certification in a reduced timescale and cost, leveraging the experience of a leading test organization such as IOTAS."

3. Harmony

A. Real-world Wi-Fi testing

Technology trends

- Increased number of multimode handsets to include Wi-Fi
- Greater spectrum crowding, e.g. LTE spectrum fragmentation
- Greater adoption of wireless versus wired connection
- Embedded Access Points (personal hotspot)
- The combination of Wi-Fi and GSM in a portable device is *the* enabler for home working, social media, online gaming, and location based services





Industry approach to Wi-Fi interoperability

- GSMA Device Field and Lab Test Guidelines
  - TS.11 requires Rich Communication Services (RCS) Wi-Fi bearer testing
- Open Mobile Alliance (OMA) is developing a Connection Management API
- CTIA Converged Devices test plan measures OTA RF performance in-lab (Tx, Rx, desense)
- No formal field trials test plan exists for challenging end-user scenarios

Harmony approach to test

- Analyse
  - Record real-life environments
  - Capture transition events including handover, coverage blackspots and connection requests
  - Re-visit over time to capture new trends
- Model
  - Replicate the real-life situation in controlled lab conditions
  - Repeatable
- Measure
  - Capture results to measure performance and user experience
  - Provide insight and comparison data

End-user scenarios

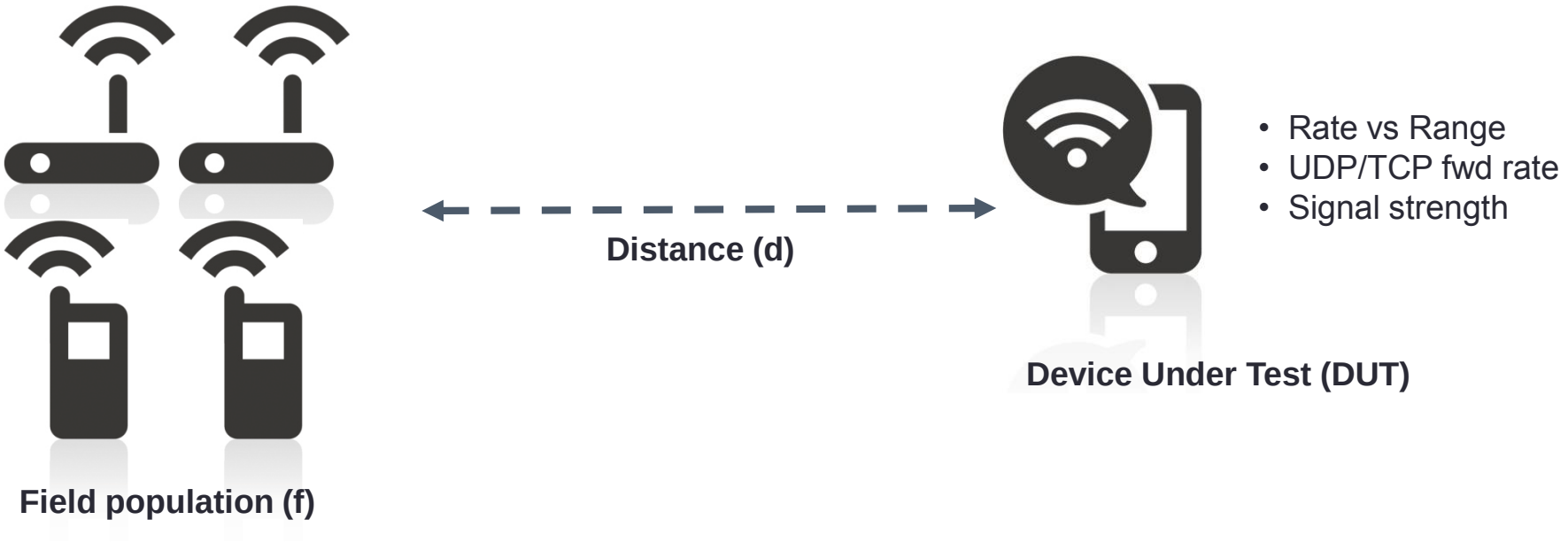
- Campus
  - Dynamic location
  - Inter-AP handover
  - Mixed media (streaming, download, mail)
  - Mixed clients (mobile, laptop)
- Cafe
  - Static location
  - Crowded population of Wi-Fi clients
  - Overlapping public and private networks
  - Enterprise security (VPN)
  - Mixed service providers

3. Harmony

B. Campus - Dynamic location

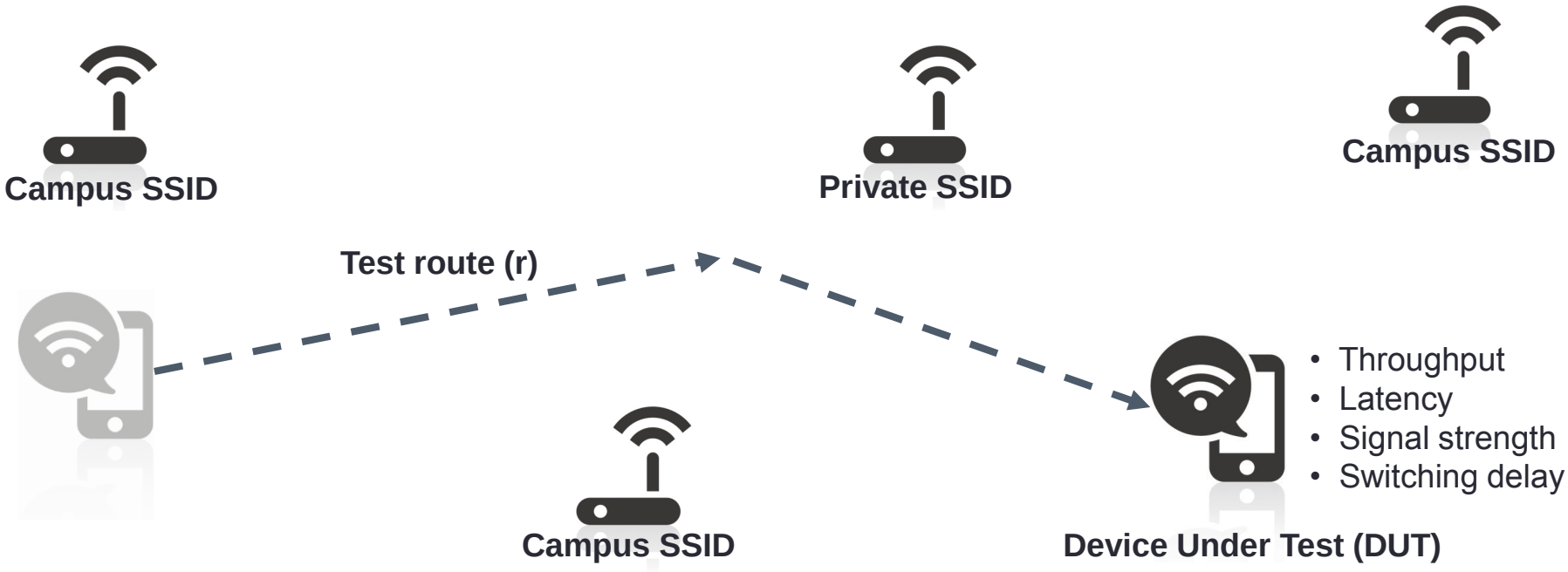
Open field test (controlled conditions)

- Key features
  - Repeatable set-up
  - Create benchmarks
  - Vary distance (d), AP type (including chipset) (f), band



Dynamic location (handover) test

- Key features
  - Travel between APs with the same SSID
  - Either IOTAS controlled conditions or real-world case
  - Standard campus trial (c.f. GSM drive test)



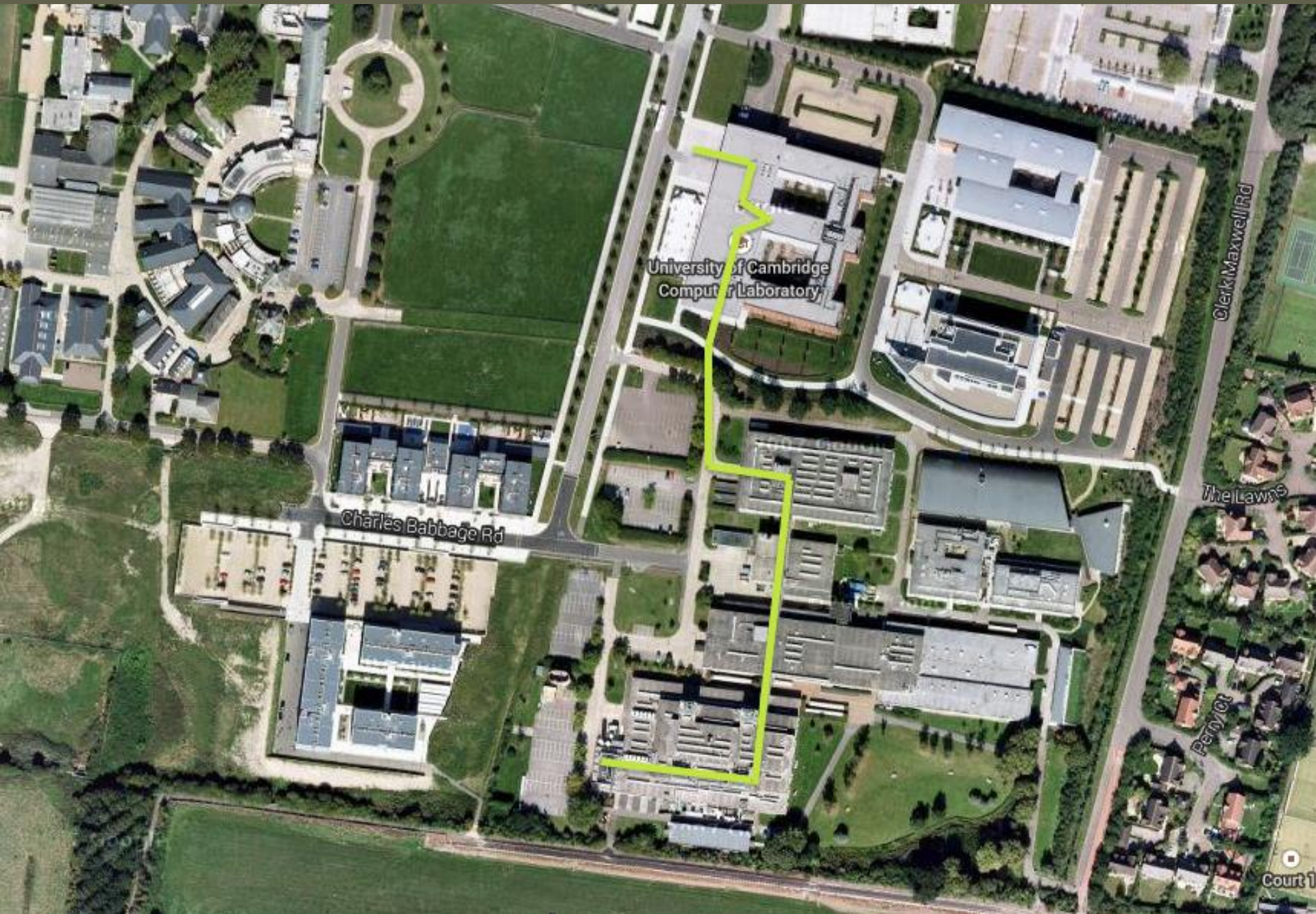
Campus modeling

- University of Cambridge
  - more than 18,000 students
  - nearly 9,000 staff
  - 31 Colleges
- Analysis
  - Aruba infrastructure (AP103, 802.11b/g/n)
  - Lapwing (captive portal) and Eduroam (WPA2-E) networks
  - Additional networks around campus for departmental work
  - Route 1 defined to include inter-AP handover and coverage gap
  - Laptop and mobile devices tested



UNIVERSITY OF CAMBRIDGE


GIVE
WAY
25


University of Cambridge
Computer Laboratory
Charles Babbage Rd
Clerk Maxwell Rd
The Lawns
Court 1

3. Harmony

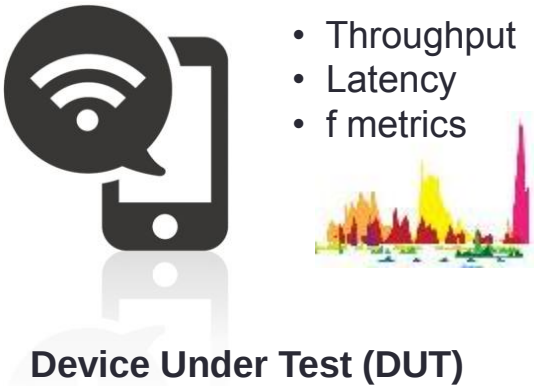
C. Café - Crowded environment

Crowded user environment

- Key features
  - High number of Wi-Fi users in field population (f) either IOTAS controlled conditions or real-world case
  - Measure DUT performance as number of client devices increases
  - Log population metrics during test, and plot performance



Field population (f)



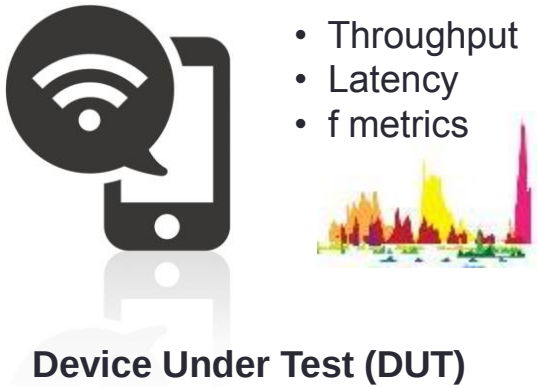
Device Under Test (DUT)

Interference testing

- Key features
  - Measure impact on Wi-Fi performance in presence of interference
  - IOTAS controlled conditions
  - GSM (including LTE), Bluetooth, microwave, ISM, DECT



Field population (f)



Device Under Test (DUT)

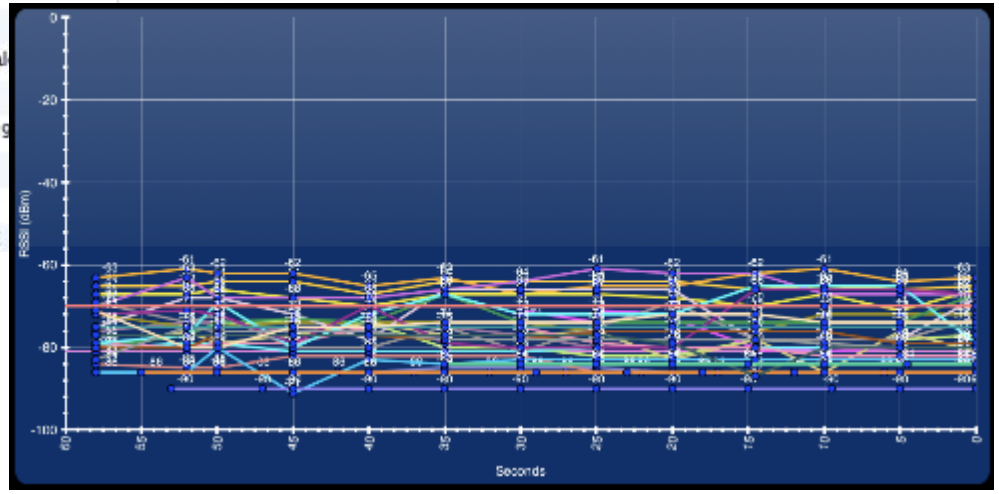
Café modelling

- Cambridge city centre
  - mixed population of residents, workers, students, tourists
- Analysis
  - initial analysis performed in busy location during busy period
  - laptop measurements to analyse Wi-Fi population



Results of real life analysis

Channel	Channel Band	BSSID / MAC Address	PHY Mode	Sig...	Noise	S/N	SSID	Security
6	2.4 GHz	Huawei Technolog...	802.11n	-67	-91	24	3MobileWiFi-D150	WPA2 Personal
11	2.4 GHz	Huawei Technolog...	802.11n	-84	-90	6	3MobileWiFi-D312	WPA2 Personal
6	2.4 GHz	Murata Manufactu...	802.11n	-81	-91	10	Android Hotspot4050	WPA2 Personal
6	2.4 GHz	Cisco Systems, Inc...	802.11g	-67	-92	25	Auto-BTWiFi	WPA2 Enterprise
11	2.4 GHz	Symbol Technolog...	802.11g	-74	-92	18	BOLSENA	WPA2 Personal
6	2.4 GHz	Cisco Systems, Inc...	802.11g	-79	-92	13	BTOpenzone	Open
6	2.4 GHz	Cisco Systems, Inc...	802.11g	-67	-92	25	BTOpenzone-Starbucks	Open
6	2.4 GHz	Cisco Systems, Inc...	802.11g	-66	-92	26	BTWifi-X	WPA2 Enterprise
6	2.4 GHz	Ruckus Wireless:0...	802.11n	-78	-91	13	Bookshop-Wireless	Open
40	5 GHz	Symbol Technolog...	802.11a	-86	-90	4	COMINO	WPA2 Personal
11	2.4 GHz	Meraki, Inc.:21:3E:AC	802.11g	-84	-92	8	CSOMERAKI01	WPA Personal
6	2.4 GHz	Ruckus Wireless:4...	802.11n	-78	-91	13	CUP-SEC	WPA2 Enterprise
6	2.4 GHz	Netgear:76:3F:F9	802.11n	-63	-91	28	Cambridge Market Hill	WPA2 Personal
11	2.4 GHz	Routerboard.com:...	802.11n	-69	-90	21	Cambs City Council WiFi	WPA2 Personal
2	2.4 GHz	Draytek Corp.:F5:...	802.11n	-75	-90	15	Christian Schultz	WPA2 Personal
6	2.4 GHz	Netgear:6B:DA:DE	802.11n	-81	-85	4	DenHaut	
6,-1	2.4 GHz	Draytek Corp.:AD:...	802.11n	-81	-82	1	DonPasqual	
2	2.4 GHz	Cisco-linksys, Llc:...	802.11n	-80	-92	12	Falcon1	
5	2.4 GHz	Hewlett Packard:C...	802.11n	-85	-92	7	HP-Print-39	
1	2.4 GHz	Aruba Networks:2...	802.11n	-90	-92	2	JW_Guest	
40	5 GHz	Symbol Technolog...	802.11a	-86	-90	4	LIPARI	
11	2.4 GHz	Symbol Technolog...	802.11g	-77	-91	14	MAGGIORE	



Results of investigation

- 22 visible networks (same SSID hidden)
- Only 2 5GHz (802.11a) networks
- Most networks using non-overlapping channels (1, 6, 11)

