From Ubiquitous Computing to Internet of Everything: Challenges and Opportunities

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Hype or genuine evolution?

1988 | 1999 - 2002 | 2005 | 2009 | 2013

Ma EC, IoT — An Cisco – coins **Internet of Everything** Things

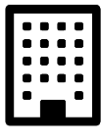
"… "network of i "The Internet of Everything (IoE) brings together ch new
pe to cars, from people, processes, data, and things to make dio-frequency
fro These object networked connections more relevant and a world of
fin Internet Prot valuable than ever before – turning information ices (e.g.
tha complex syst into actions that create new capabilities, richer or, etc.) that
so information f experiences, and unprecedented economic nation
hig use actuators opportunity for businesses, individuals, and heralding the
so fitting, so nat countries." e internet (of
thinking about it. way for compu data and people) acquires a new dimension to become an Internet of Things."

Numerous opportunities

Healthcare and assisted living

Transportation

Environment monitoring and agriculture



Smart buildings

Many more

Interconnecting many devices that exchange (big) data is challenging

How to model and predict the behaviour of complex systems?

How to ensure reliable connectivity and optimally share communictions infrastructure?

How to aggregate large data sets and exploit only context specific information in real-time?

How to preserve user privacy while achieving some utility from data processing?

How to ensure Internet-connected ‘things’ are secure and easy to use?

Different perspectives needed

UK researchers wrote Ubicomp manifesto in 2006* – some challenges facing ubiquitous system design still hold

Theoretical perspective: rigorous models that capture system behaviour at different levels of abstraction.

Engineering perspective: architectural and network challenges posed by large scale, heterogeneous, and dynamic nature.

Experience perspective: understand what principles underpin human-machine interaction and how a ubiquitous computing society might be shaped from a socio-technical perspective.

*D. Chalmers, M. Chalmers, J. Crowcroft, M. Kwiatkowska, R. Milner, E. O'Neill, T. Rodden, V. Sassone, M. Sloman, "Ubiquitous Computing: Experience, Design and Science", A Grand Challenge in Computing Research sponsored by the UK Computing Research Committee, 2006.

Application specific challenges

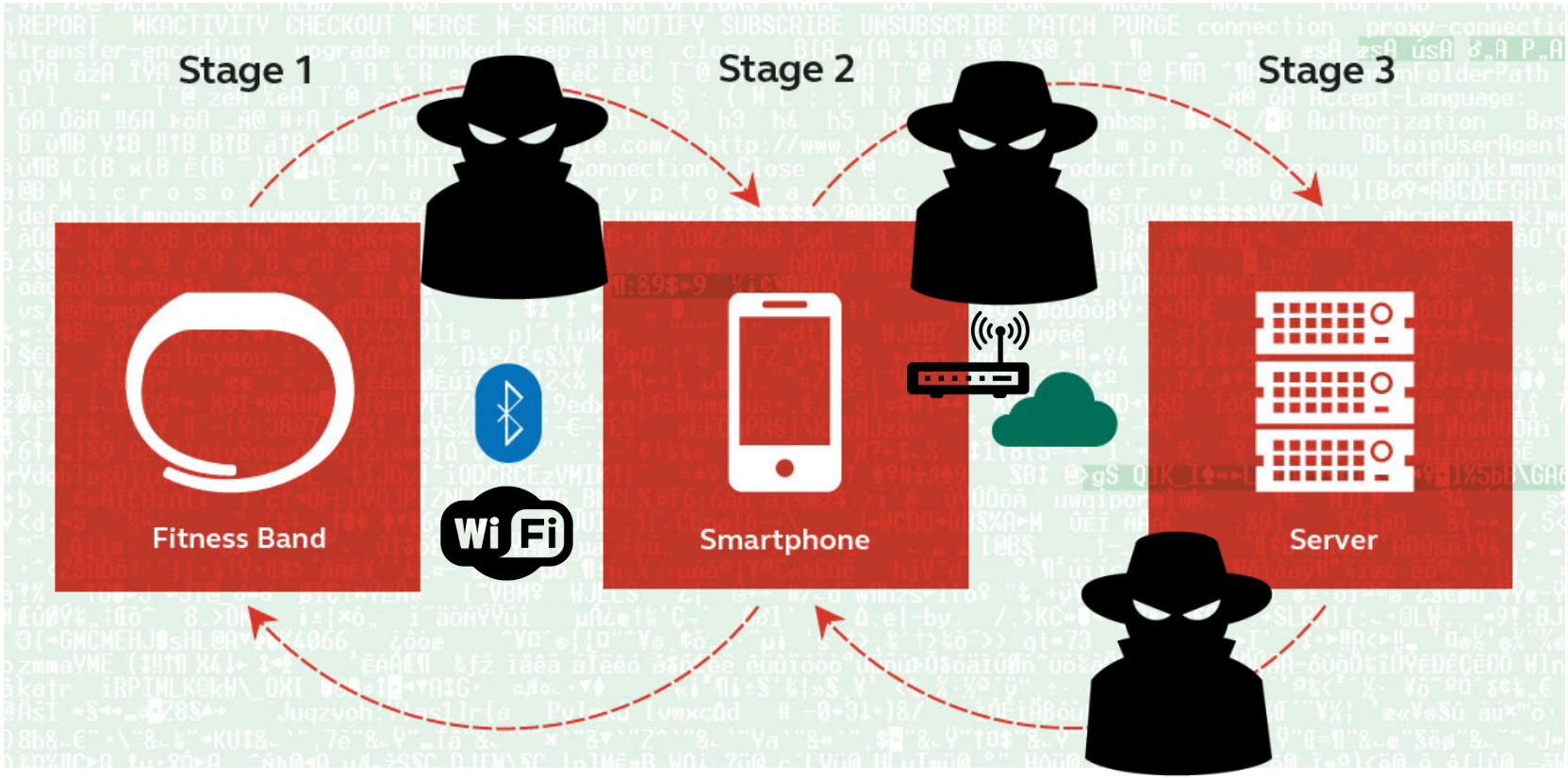
Computationally/energy constrained vs unconstrained devices

Communication type (decentralised vs scheduled and range (long vs short)

User interface (display, keys, touch, voice, gestures)

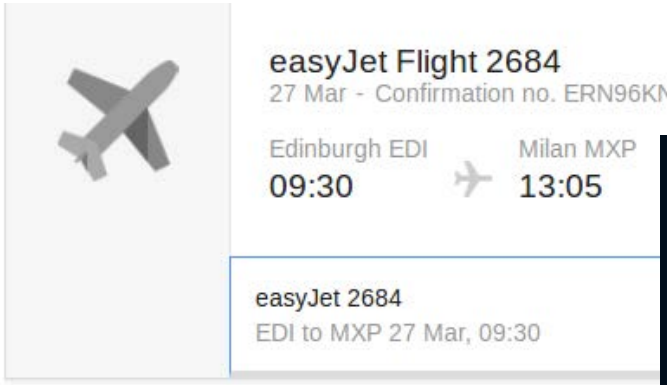
Example: Wristband fitness trackers (activity, sleep, heart rate monitoring)

Operation model



Adapted from securelist.com

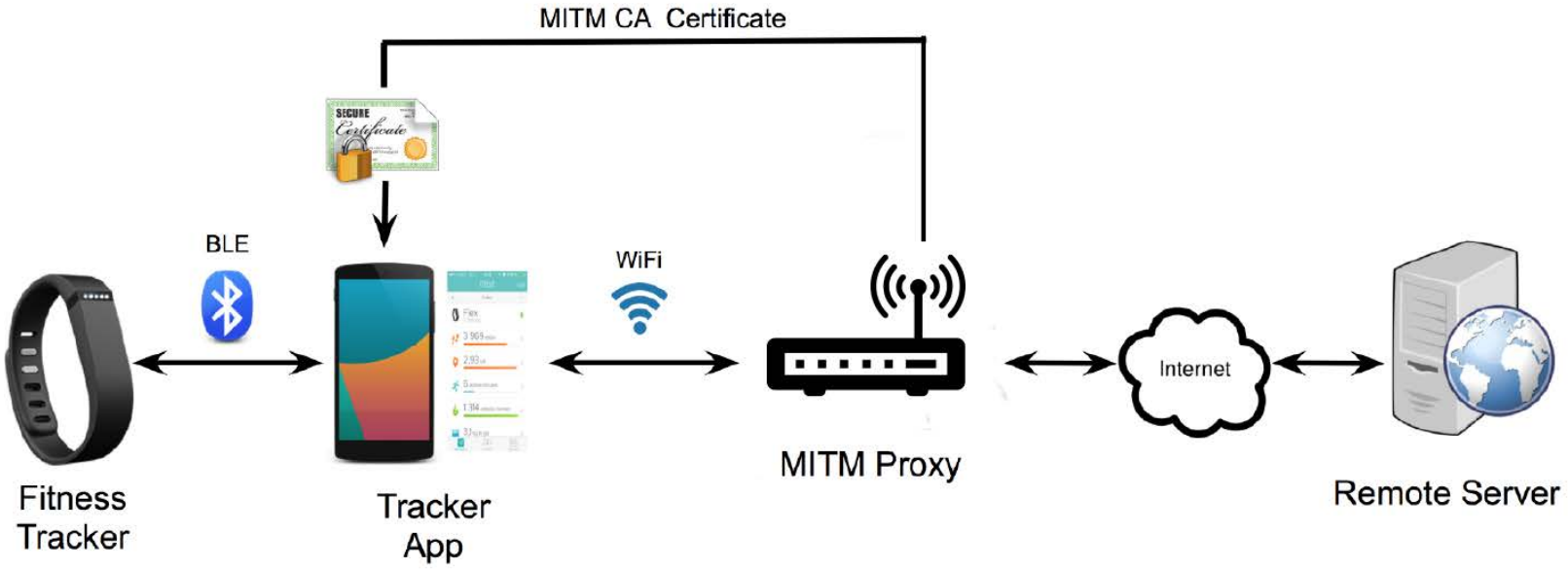
Surveillance at 10,000m




```
paul@batcat:~$ date
Mon 27 Mar 11:17:42 BST 2017
paul@batcat:~$ sudo hcitool lescan
[sudo] password for paul:
LE Scan ...
4F:FF:19:3D:F3:A6 (unknown)
48:94:29:F3:4E:BC (unknown)
69:20:9F:A7:78:06 (unknown)
E7:E4:B1:19:18:2B One
46:38:32:3A:5A:63 (unknown)
D8:CE:27:74:9B:FE Charge 2
E3:00:C9:B1:BA:52 Charge 2
E2:3E:C8:E6:7F:62 vívosmart HR
7B:BF:CD:46:4F:09 (unknown)
88:C6:26:01:05:08
77:D0:E4:0B:E3:2F (unknown)
4A:60:ED:6F:38:DB (unknown)
75:C1:8F:69:07:1C (unknown)
```

13 devices detected within <1 minute

Security still an afterthought



- Intercepting sensitive personal information is possible
- Injection of fake activity reports to gain rewards
- Compromising victim's personal statistics

H. Fereidooni, J. Classen, T. Spink, P. Patras, M. Miettinen, A.-R. Sadeghi, M. Hollick, M. Conti, "Breaking Fitness Records without Moving: Reverse Engineering and Spoofing Fitbit", to appear in Proc. RAID, Atlanta, GA, USA, Sept. 2017.

Smart Homes

A range of appliances controllable via a mobile app

Source: eurocomms.com

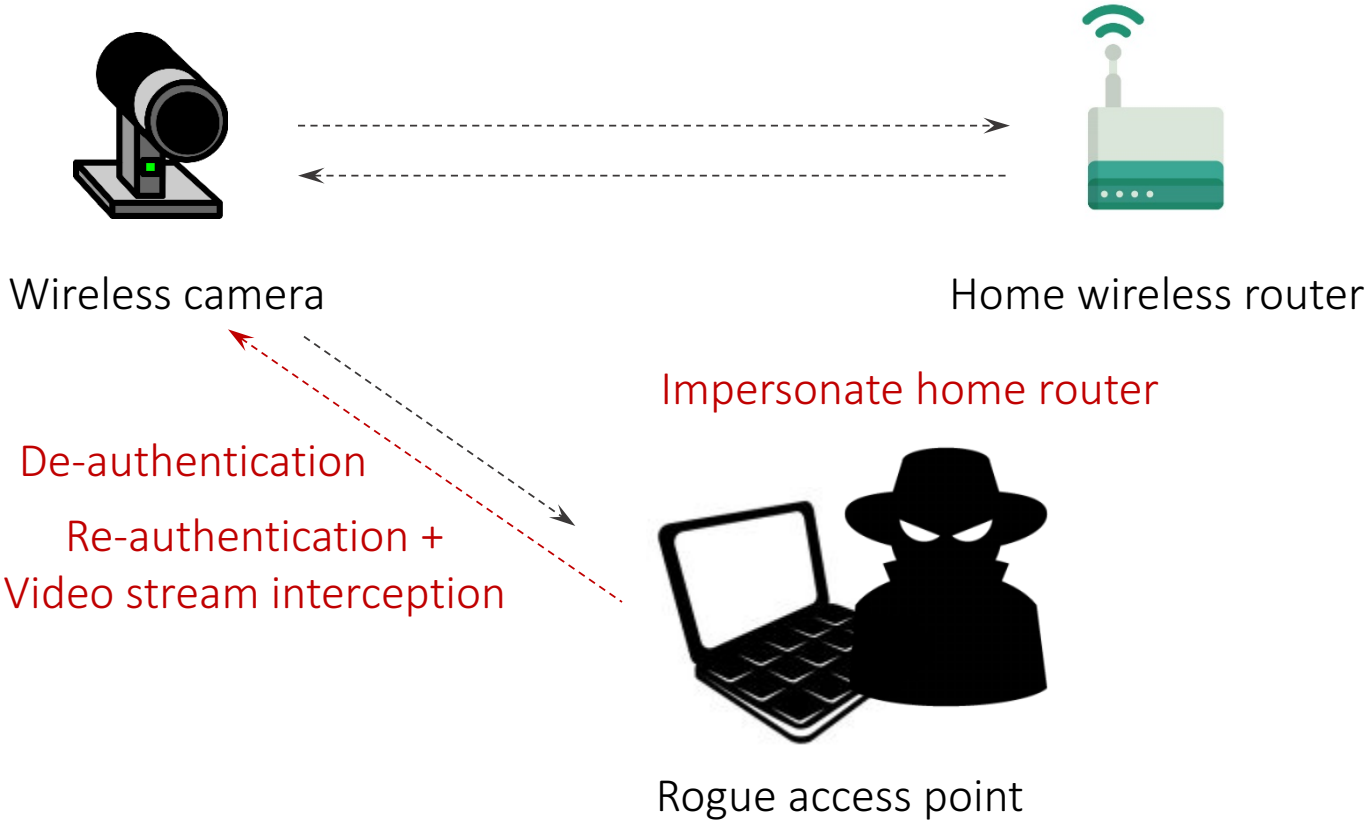
Obvious benefits…

- Lower carbon footprint
- Personalisation (access control)
- Increased comfort and safety (?)

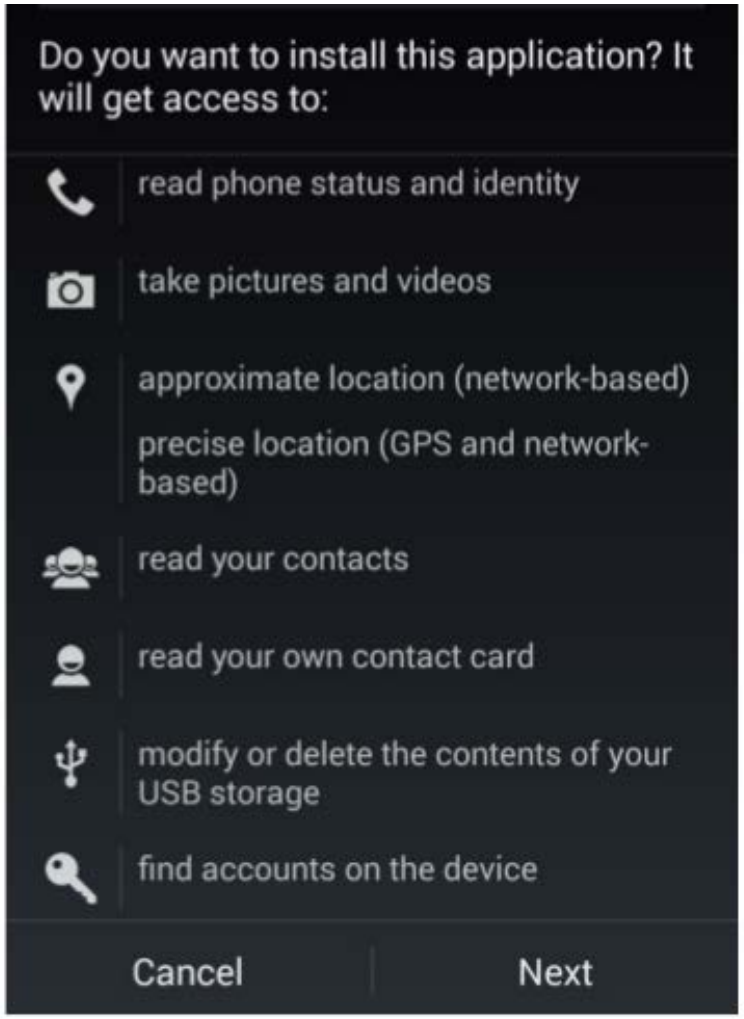
…come with risks

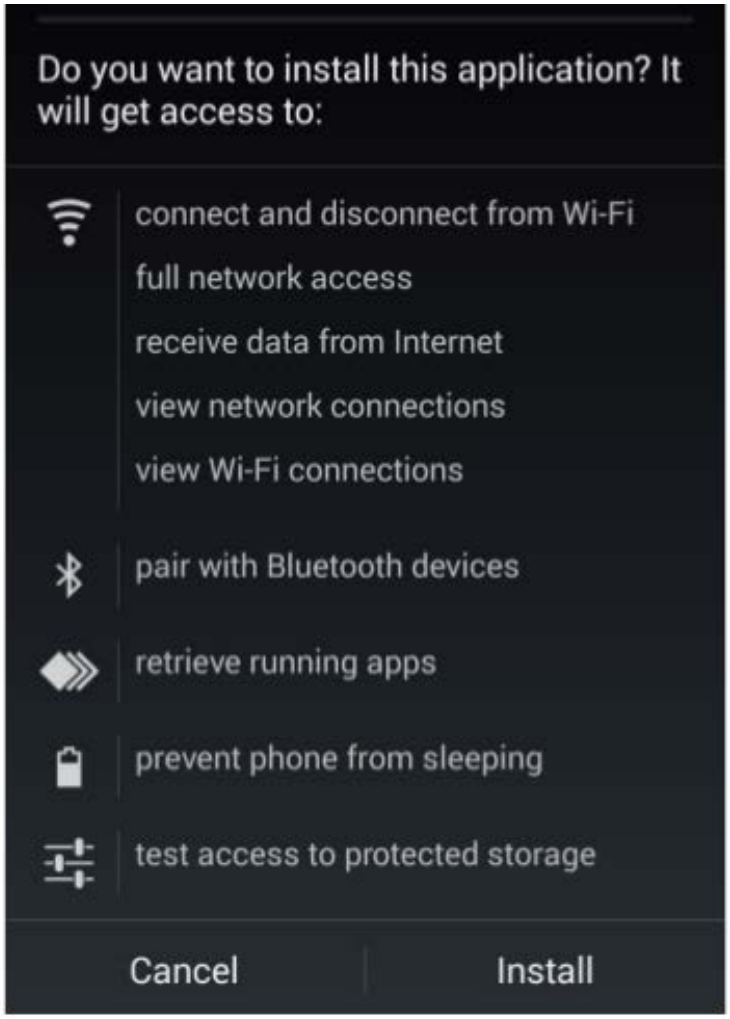
- Communication again wireless and subject to abuse
- Control via software (app) – risk of malware and privileges abuse
- Hijacking and weaponisation

Example: Taking down a surveillance camera



Example: Faking IoT device and exploiting generous app permission





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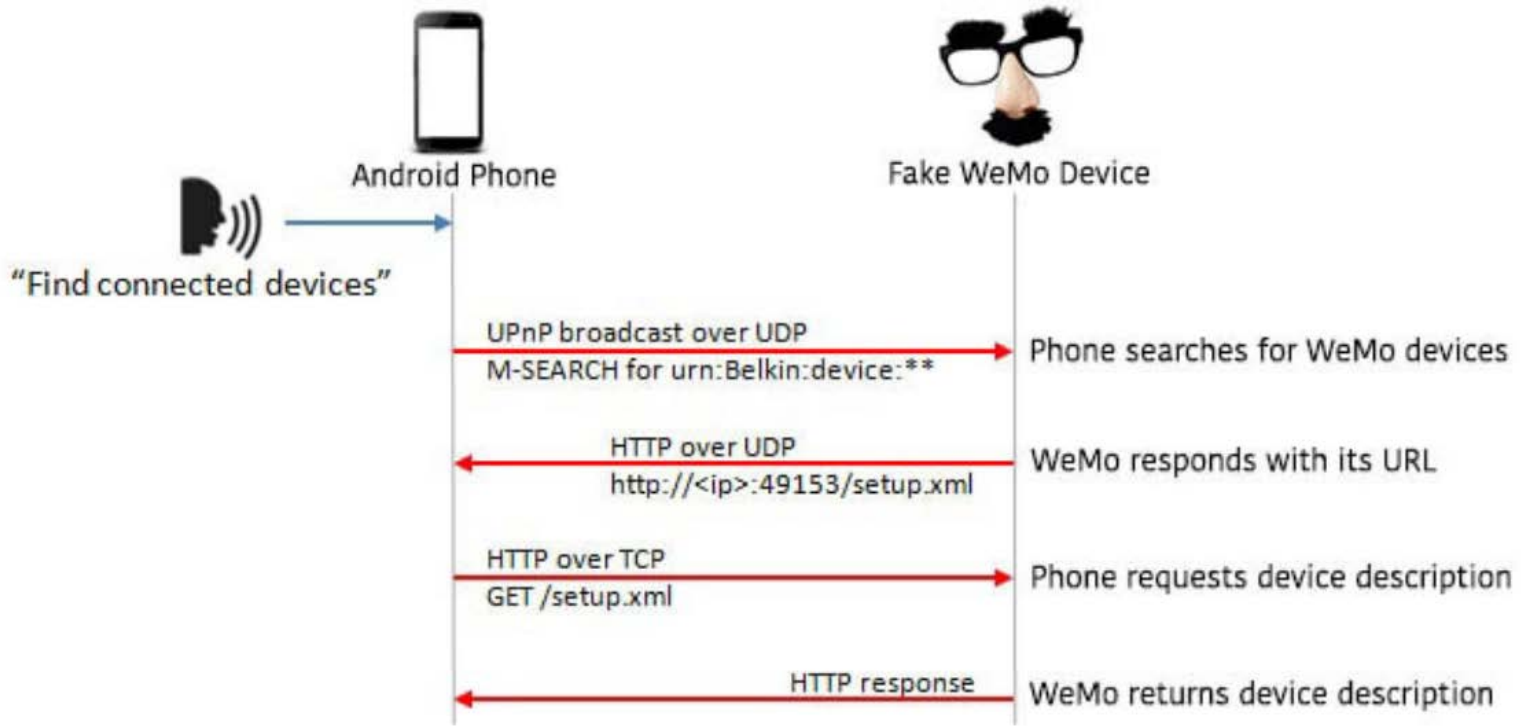

- Possible to ask phone app to send photos taken by user, list of contacts, and other sensitive information

What we can do

Help design systems with scalability in mind.

Work to achieve strong encryption with limited computing capabilities.

Standardise security by design.

Define sustainable development of new devices.

Train developers/engineers that understand embedded systems, programming, and security.