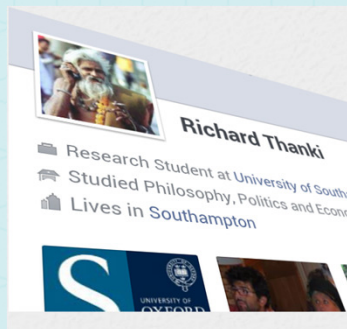# THE IMPORTANCE OF LICENCE-EXEMPT TECHNOLOGIES

iWeek 2012 presentation
Richard Thanki – ICSS,
University of Southampton

SOME INTRODUCTIONS / look who's talking

Me

Author of 2009 and 2012 studies, former Ofcom economist and deputy to the UK Independent Spectrum Broker, current PhD researcher

ICSS

£12m institute focused on complex adaptive systems, encompassing areas such as genetics, climate science and economics

Microsoft

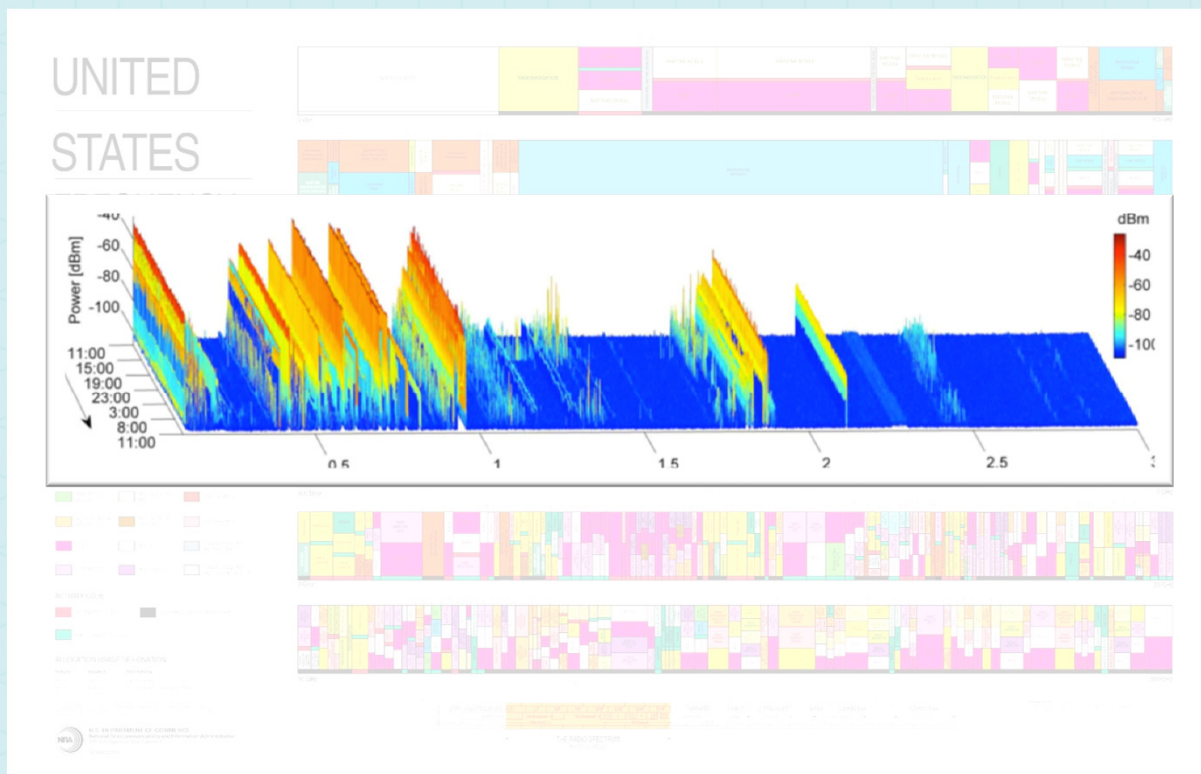Important financial assistance required to complete 2009 and 2012 studies

SUMMARY / why licence-exempt technologies are important

- The title of my talk gives away the conclusion of the report!

- Demonstrating the importance of licence-exempt technologies helps policy-makers make decisions

- The content of this presentation:
  1. Introducing licence-exempt technologies and spectrum
  2. The importance of licence-exempt technologies to the future of the internet
     - Connecting people
     - Connecting machines
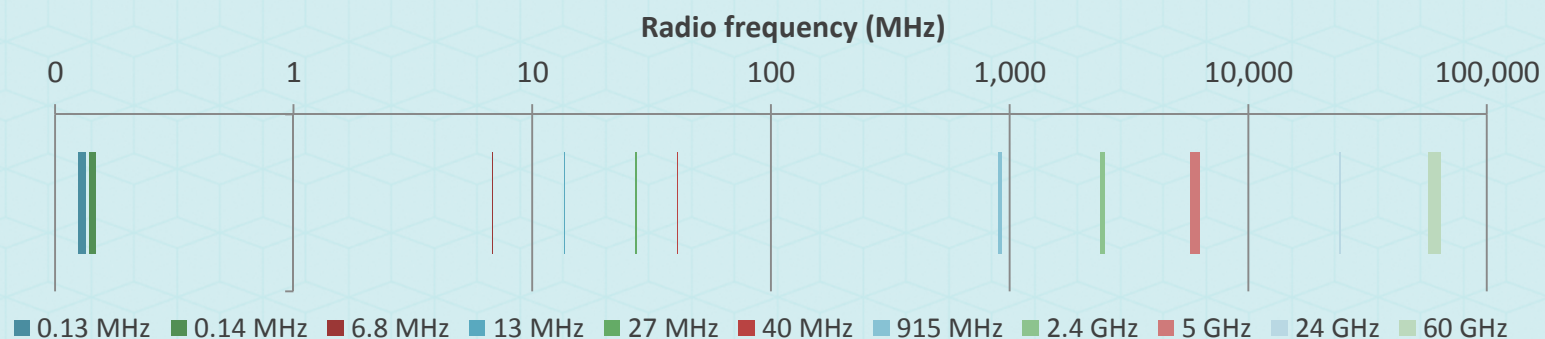   - Creating a more robust architecture

THE RADIO SPECTRUM AND GOVERNMENT CONTROL

- In 1923 a US court ruled that the government could not control radio operators.
  - an explosion of new stations – broadcasters engaged in 'power races' and 'frequency races' to drown out each others' signals and listeners were often only able to tune in to garbled static.
- In response to this situation, civil actions were filed and the courts began to judge on the usage rights to spectrum.
  - Hazlett (1990) presents fascinating details of this era and the common law that began to be built to address this situation.
- The Radio Act of 1927 established the Federal Radio Commission, a forerunner of the FCC.
  - Cut short the civil system

- **Around the world, government control of spectrum is based on the idea of preventing interference**

NEATLY DIVIDED LOTS

NEATLY DIVIDED LOTS…BUT A VIRTUAL GHOST TOWN

SPECTRUM FOR LICENCE-EXEMPT USAGE

Radio frequency (MHz)

| 0 | 1 | 10 | 100 | 1,000 | 10,000 | 100,000 |

■ 0.13 MHz ■ 0.14 MHz ■ 6.8 MHz ■ 13 MHz ■ 27 MHz ■ 40 MHz ■ 915 MHz ■ 2.4 GHz ■ 5 GHz ■ 24 GHz ■ 60 GHz

- In 1985 the FCC authorised the use of the ISM (Industrial, Scientific and Medicine) bands for low powered communications devices on a 'licence-exempt', or 'unlicensed', basis
  - Strict power limits and no protection
  - Full of interfering high-powered uses…junk!

THE SUCCESS OF THE EXPERIMENT / by numbers
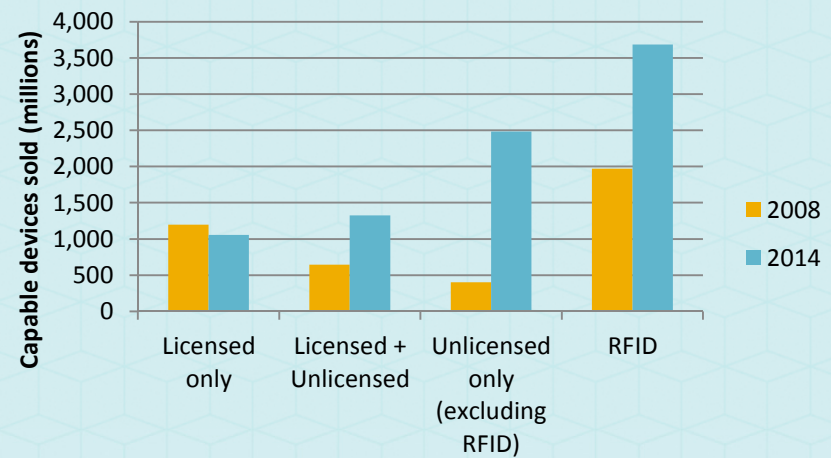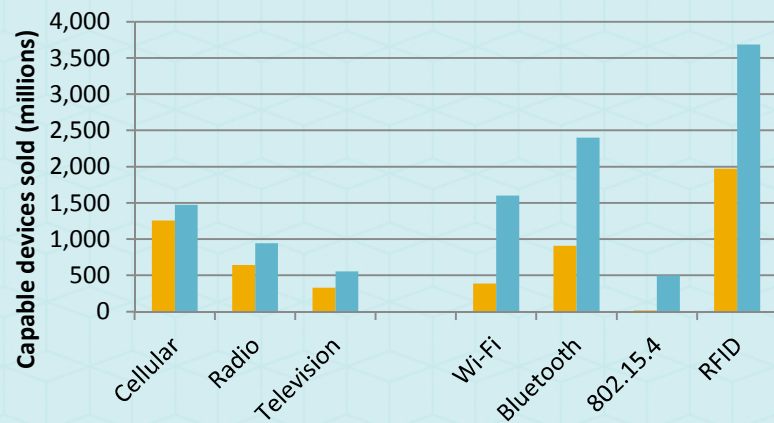
THE SUCCESS OF THE EXPERIMENT / by variety

	Consumer	Commercial	Educational	Healthcare	Industrial	Government
Wireless LANs 802.11/Wi-Fi	Broadband extension					
	Local area networks					
	Consumer electronics	Commercial hotspots	Campus networks	Records management	Process monitoring	Municipal networks
	Home monitoring	Card payments			Process control	Wide-area systems control
					Process automation	
Wireless PANs 802.15.1/Bluetooth	Personal area networks					
	Mobile phone headsets			Medical devices		
	Remote controls	Bluetooth marketing				
RFID	Contactless payment			Asset tracking		
	Transport payment	Supply chain		Human implants		
	Identification	In-store		Drug authenticity		
Low data rate wireless PANs 802.15.4/Zigbee	Smart metering					
	Sensor networks					
	Home control	Premises control			Exact process monitoring	
					Exact process control	
					Exact process automation	
Microwave/WiMAX	Mobile and fixed broadband					
		Point-to-point connections				
WirelessHD, WiGig	Wireless HD displays					
	Very high rate date transfer					

THE SOURCES OF SUCCESS

Direct to consumer

- No intermediaries controlling investment decisions
- Moves at a continuous speed (not waves) and at the speed of the consumer market

An open market/No barriers

- Open to any equipment manufacturer
- Open to any service provider
- Leads to tremendous competition throughout the market
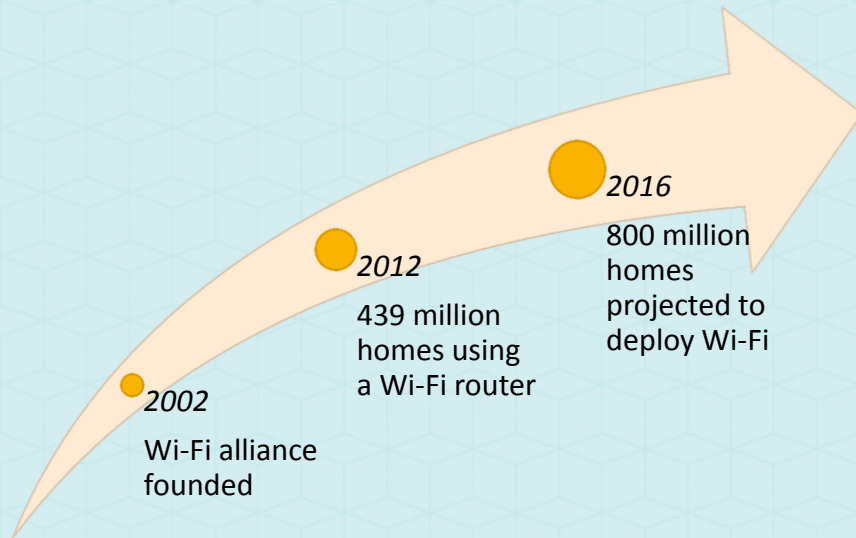- Lowers equipment costs

Lack of protection

- Not having clean spectrum has driven innovation
- Spread spectrum / OFDM / MIMO are all technologies that have been introduced in Wi-Fi many years before cellular
- (Early predictions of max 40 access points per square km – Paris now has 20,000 per sq km)

CONNECTING ALL THE PEOPLE / Wi-Fi after 10 years

2002
Wi-Fi alliance founded

2012
439 million homes using a Wi-Fi router

2016
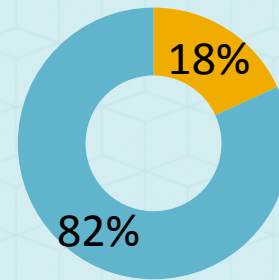800 million homes projected to deploy Wi-Fi

- 25% of all households use Wi-Fi – 439 million home Wi-Fi access points
  - 85% penetration in homes with fixed broadband

- The economic value created by enhancing the value of fixed broadband is $46 to $87 billion of consumer surplus each year.
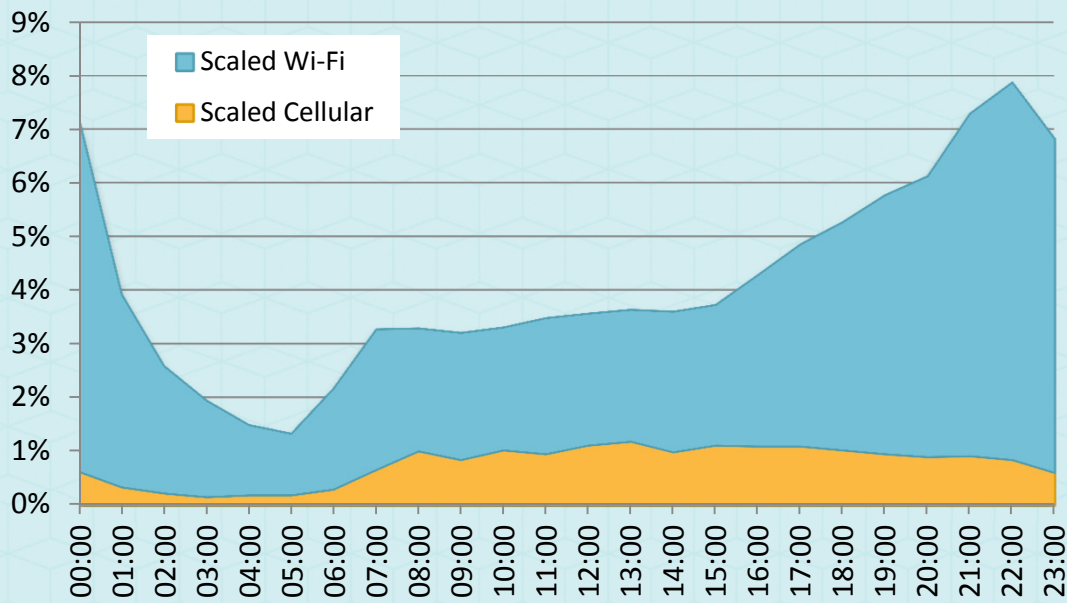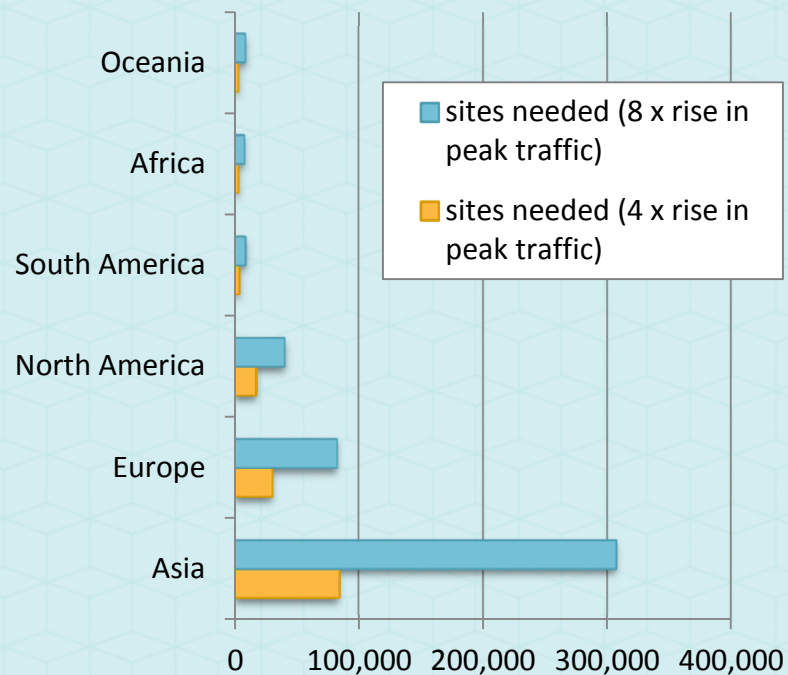
CONNECTING ALL THE PEOPLE / a world without Wi-Fi

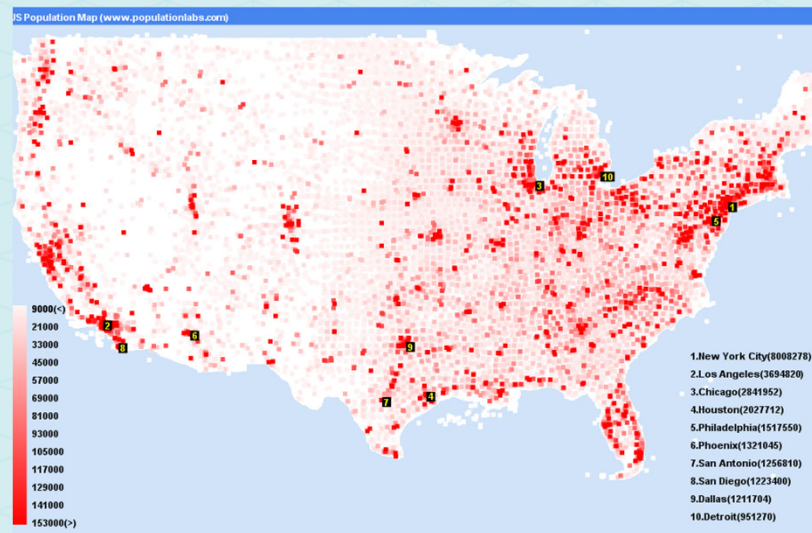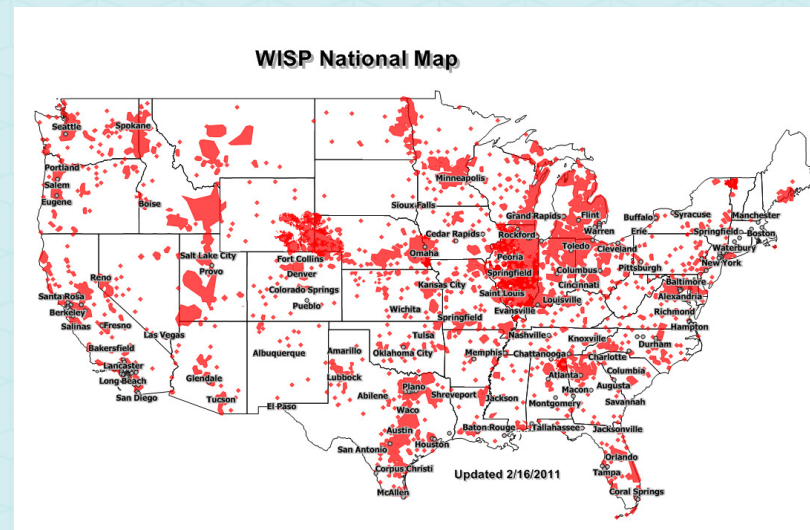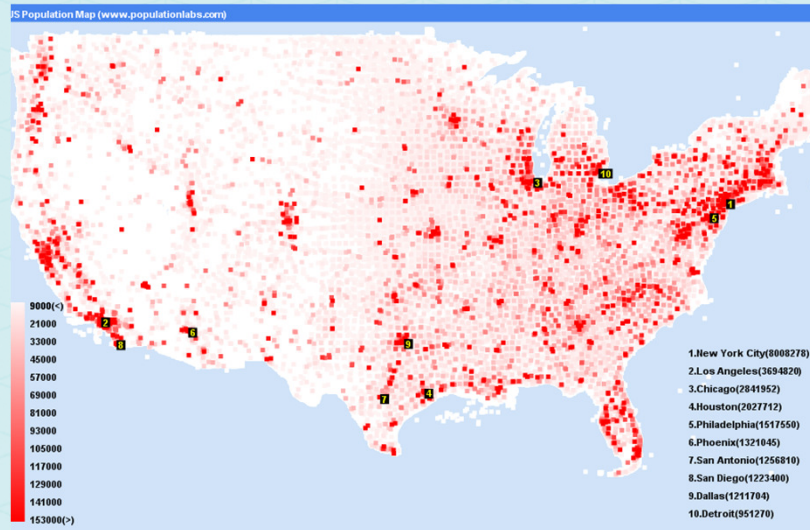

- This year 140,000 to 450,000 extra sites would be needed (an additional 8 – 20% sites worldwide)
  - A minimum of 800 in South Africa

- At a cost of $30 - $90 billion (very conservative)

- As traffic levels are rapidly rising this number could escalate substantially in the coming 5 years

CONNECTING ALL THE PEOPLE / wisps

US Population Map (www.populationlabs.com)

9000(<)
21000
33000
45000
57000
69000
81000
93000
105000
117000
129000
141000
153000(>)

1.New York City(8008278)
2.Los Angeles(3694820)
3.Chicago(2841952)
4.Houston(2027712)
5.Philadelphia(1517550)
6.Phoenix(1321045)
7.San Antonio(1256810)
8.San Diego(1223400)
9.Dallas(1211704)
10.Detroit(951270)

CONNECTING ALL THE PEOPLE / wisps

CONNECTING ALL THE PEOPLE / a long quote (the only one, I promise)

"WISPs do this without subsidy…and grew using money generated from the actual business. They don't have 6 figure base salaries and they don't burn through stockholder money to create their golden parachute. Being small business owners they also have a keen sense of the market space and they can react quickly to changes. Their equipment has advanced much more rapidly than other broadband technologies. Today they are capable of delivering 5, 10, 15 and even 20 meg connections to the consumer. They have the lowest cost per home passed of any broadband technology. It's a novel approach to the Telecom business model."

Brian Webster

CONNECTING ALL THE PEOPLE / future opportunities

Urban WISPs

New 24GHz and 5GHz technologies can deliver cost-effective superfast broadband

Authentication

Initiatives such as Passpoint will allow for zero configuration connections to access points
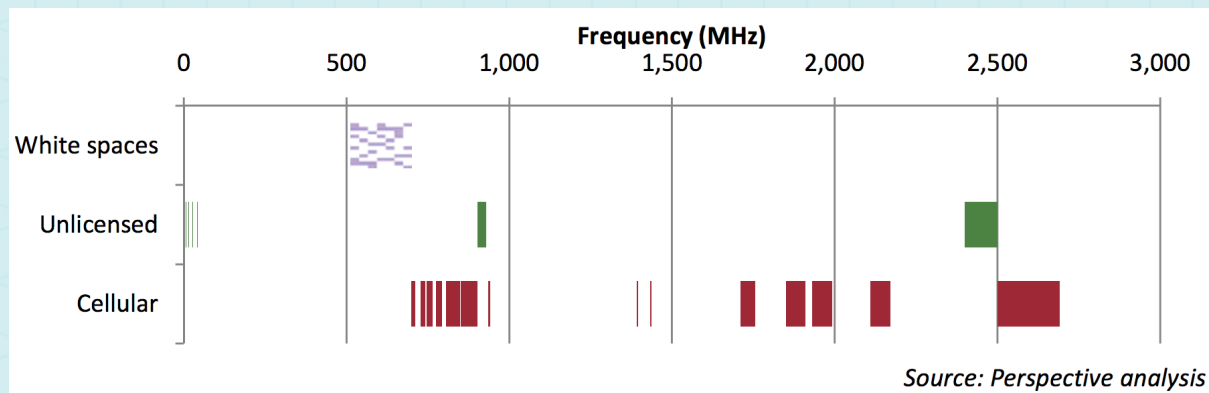

Radical models

Authentication may allow new models which aggregate existing capacity

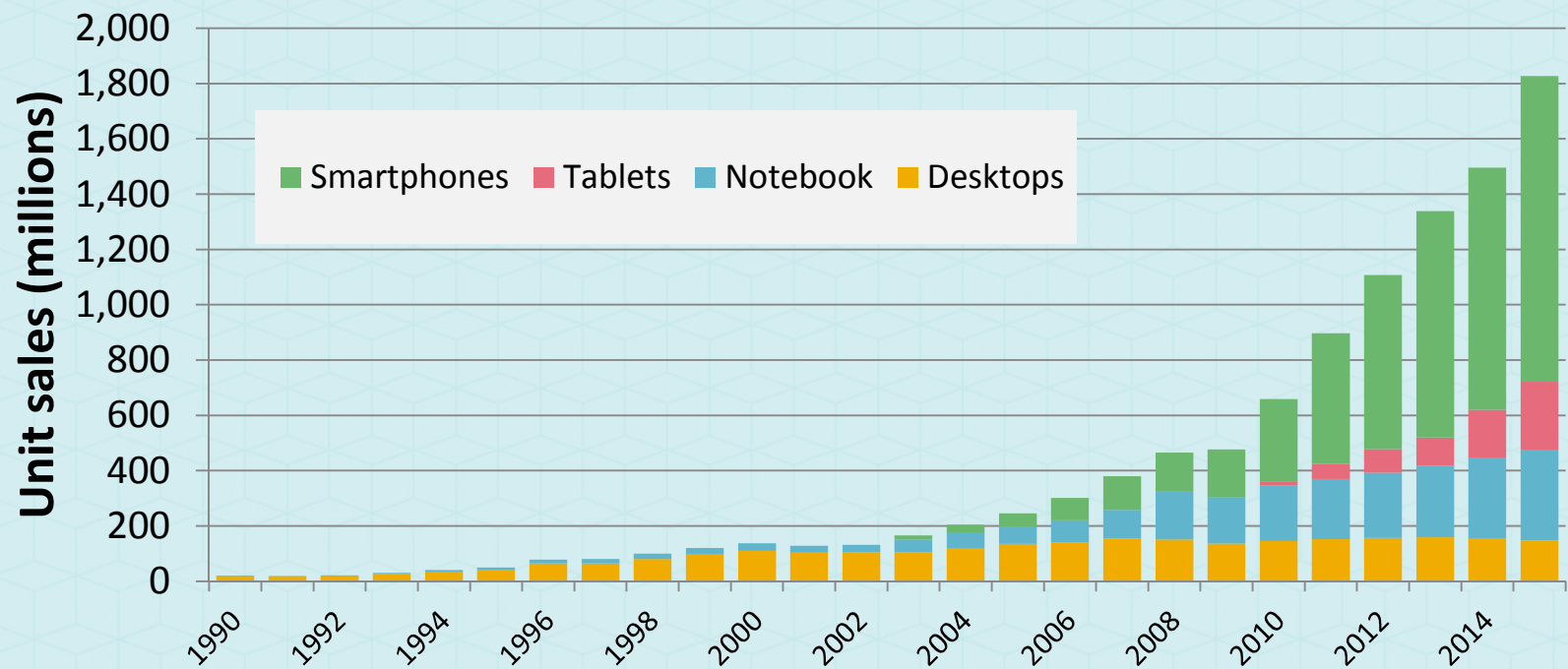## CONNECTING ALL THE PEOPLE / the TV white spaces

- Existing deployments in licence-exempt limited by the properties of 2.4/5 GHz spectrum
  - Limits applicability in difficult rural areas
- The TV white spaces will provide on average over 100MHz of prime spectrum
  - Trials taking place in UK, South Africa, US, Korea and many other nations

Source: Perspective analysis

CONNECTING EVERYTHING ELSE

CONNECTING ALL THE THINGS / a substantial human internet

Unit sales (millions)

Legend: Smartphones, Tablets, Notebook, Desktops

X-axis: 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014

Y-axis: 0, 200, 400, 600, 800, 1,000, 1,200, 1,400, 1,600, 1,800, 2,000

Source: Various

CONNECTING ALL THE THINGS / a MUCH bigger machine internet

Unit sales (millions)

Microcontroller sales

Computer and smartphone sales

30,000
25,000
20,000
15,000
10,000
5,000
0

1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014

Source: Various
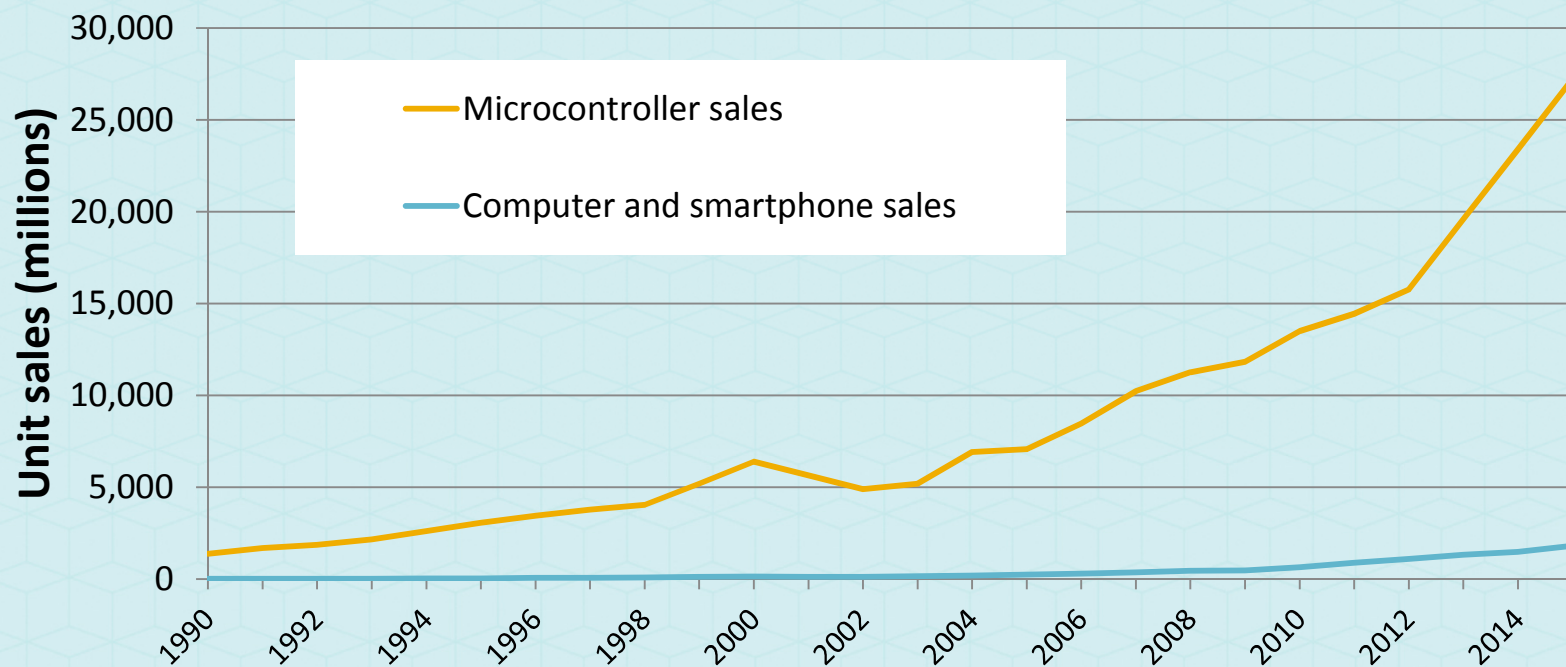
CONNECTING ALL THE THINGS / the Internet of Things

In communications
- Mobile phones
- Fixed line phones
- Fax machines
- Routers

Inside PCs and Smartphones
- Monitors
- Touchscreens
- Wi-Fi chipsets

In the home
- TVs, DVD players
- Games consoles
- Toys
- Appliances

In medicine
- Dialysis machines
- Defibrillators
- Ventillators
- Pacemakers

In vehicles
- Antilock brakes
- Fuel injection
- Climate control
- GPS

In the military
- Aircraft
- Armoured vehicles
- Missiles
- Radios

In cities
- Street lighting
- Traffic control systems
- Toll booths

In the environment
- Pollution/air quality monitors
- Weather stations

In industry
- Control circuitry
- Machine tools
- Monitors/sensors

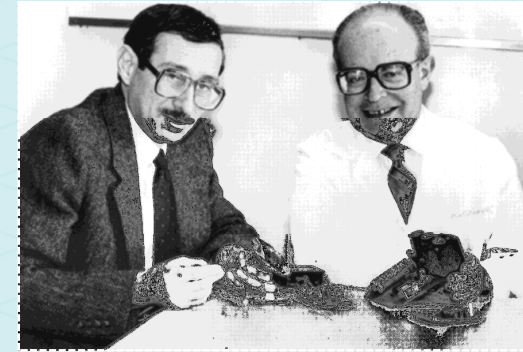## CONNECTING ALL THE THINGS / the Internet of Things

Connected Grape Vine

- Sensors to check soil moisture, temperature and light intensity information
- Actuators to control drip irrigation system
- Trialled and described by Xiang 2011

Connected Bridge

- Wireless sensors monitors the pressure and vibrations in the structure
- Products already in use from Motorola, Innodev, Microstrain etc.
- Systems described by Xu 2004, Pakzad 2008, Harms 2010

Connected Heart

- Modern pacemakers and internal defibrillators constantly monitor heart activity
- Can upload information and be programmed wirelessly
- Developed by Elmqvist 1958, Mirowski 1978

CONNECTING ALL THE THINGS / the scale of possibilities

	Today	Cisco and Ericsson predictions	Our prediction	IBM's prediction
Number of connected devices	4 bn	50 bn	100 bn	1 tn
Forecast Year	2012	2020	2020	2014
Pairwise connections	8×10^{18}	1.25×10^{21}	5×10^{21}	5×10^{23}
Ratio against today	1	156	625	62500

Even if each new machine connection generates only one-hundredth of the value of one of today's human connections, the economic value generated by the internet by 2020 would be $1.4 to $2.2 trillion per year – around five times the value generated by the internet today.

CONNECTING ALL THE THINGS / the role of LE technologies

Share of machine connections
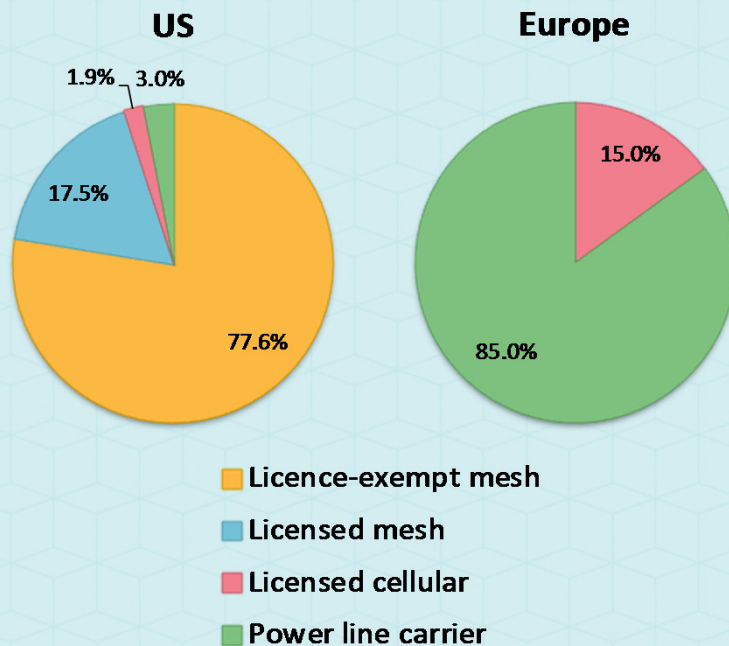
- Licensed
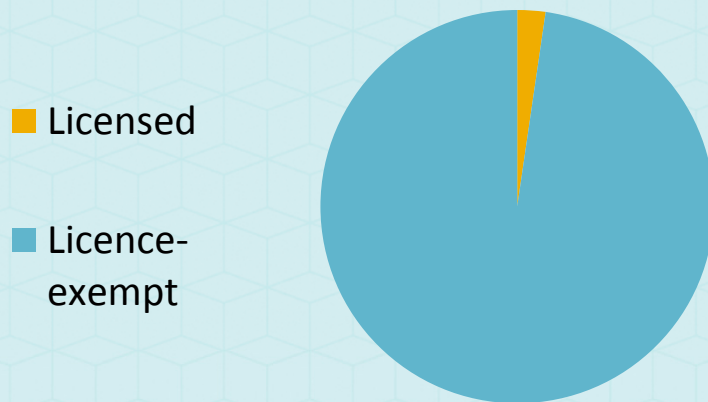
- Licence-exempt

- Licence-exempt connections will dominate the internet of things

- Technical considerations
  - Latency/network control
  - Battery life energy usage
  - Options – Wi-Fi, Bluetooth, Zigbee etc…

- Cost considerations
  - No ongoing subscription fees

CONNECTING ALL THE THINGS / the Smart Grid

Today's grid
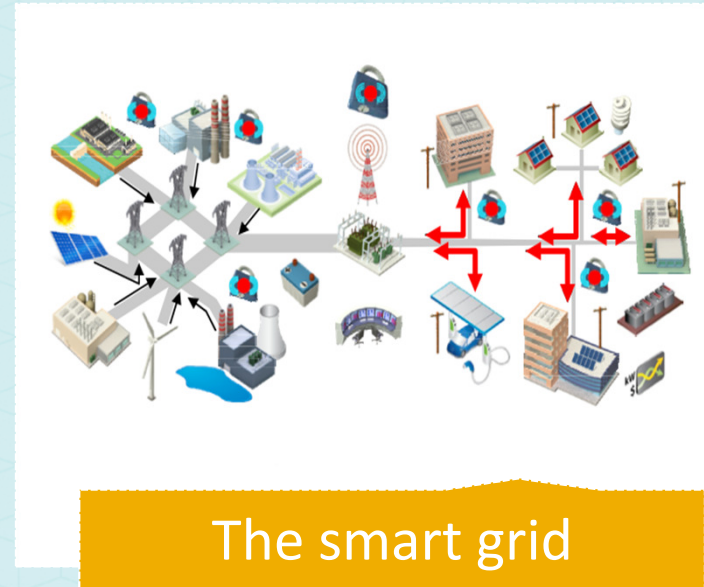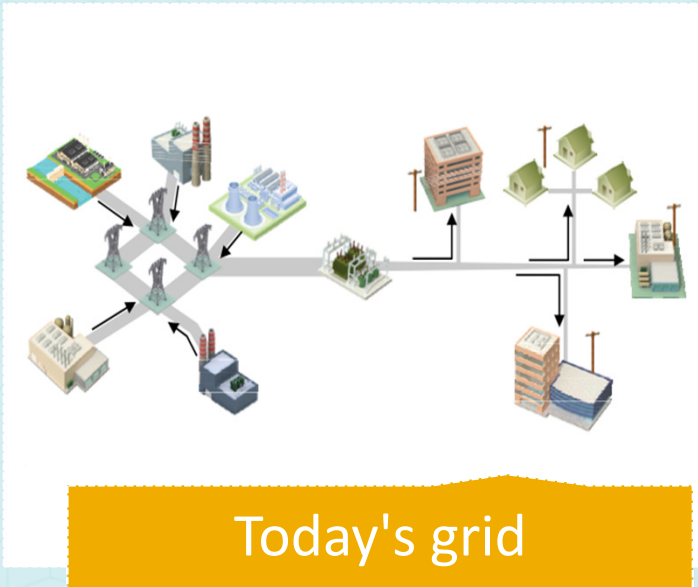
The smart grid

- Smart metering is at the heart of the smart grid
  - (real time demand supply info, allowing customers to generate and store power, creating micro-markets)

Diagrams: EPRI

CONNECTING ALL THE THINGS / the Internet of Things

US

1.9%   3.0%

17.5%

77.6%

Europe

15.0%

85.0%

■ Licence-exempt mesh
■ Licensed mesh
■ Licensed cellular
■ Power line carrier

- 900MHz licence-exempt mesh dominates the US market

- This band is not useful in Europe, causing operators a dilemma:
  - Expensive, uncertain coverage cellular systems
  - Slow powerline systems

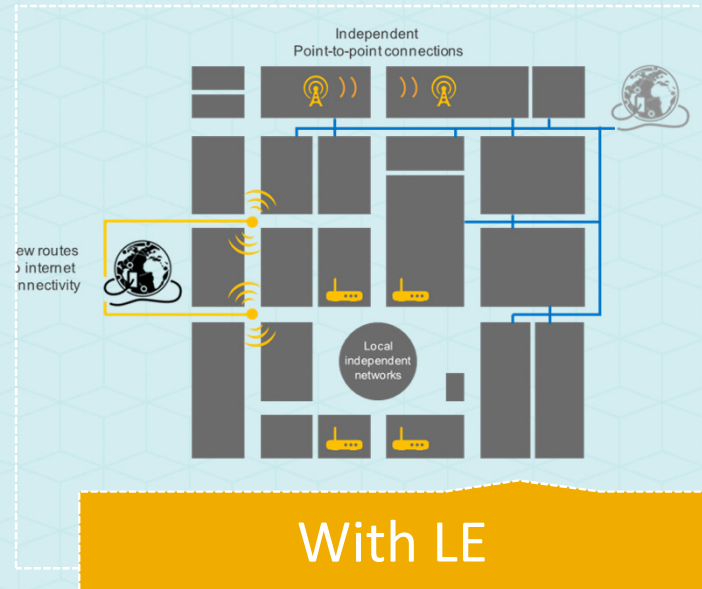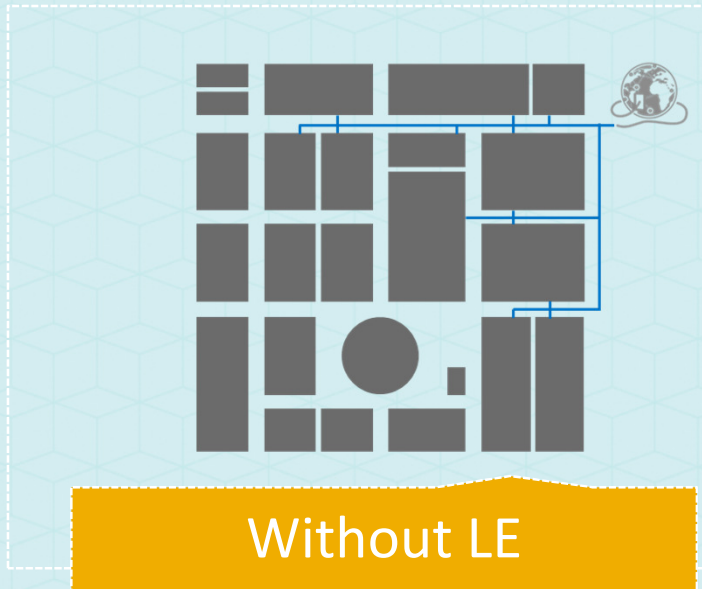- A 6 month delay for Europe would cost its economy $37 – 56 billion

Chart data: Yochai Benkler

RESILIENCE AND ADAPTABILITY

ROBUST AND ADAPTABLE NETWORKS / examples

Robust human and natural systems

ROBUST AND ADAPTABLE NETWORKS / a diverse architecture

Without LE

Independent
Point-to-point connections

New routes
to internet
connectivity

Local
independent
networks

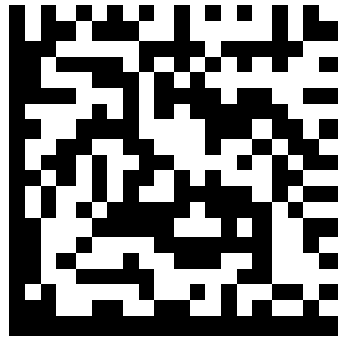With LE

ROBUST AND ADAPTABLE NETWORKS / emergencies

- In emergency situations, (aftermath of a natural disaster or terrorist or military attack) telecommunications networks often fail
  - repair requires specialised personnel or replacement equipment – may not be available or forthcoming.
- Deployment of a licence-exempt network may not require any specialised equipment.
  - Off-the-shelf or repurposed home and office Wi-Fi access points can be stitched together to create communication networks.
- Such a response was seen in response to the Japanese Tsunami, Hurricane Katrina and the Haiti earthquake.
  - FON made its network of 500,000 Wi-Fi hotspots in Japan open access
- Japan is investigating the use of white space technology specifically for this purpose
  - Range and propagation makes it ideal

POLICY CHALLENGES

- The White Spaces
  - Western Cape trial important but other countries leading in putting into place the regulation needed to free this band.

- Other non-interfering uses
  - Techniques used in TV band (spectrum sensing/databases) could be extended. New intelligent devices will best function in a more liberal policy environment.

- The balance between licensed and licence-exempt spectrum
  - 2.4GHz band achieves **30 times** the aggregate spectral efficiency of any licensed band – possibly the most economically valuable spectrum in the world

- The challenge of rural broadband
  - Licence-exempt modes of delivery may be the most cost effective way of delivering broadband – with the right regulations entrepreneurs will deliver the infrastructure without subsidy!

THANK YOU!

Questions?

http://bit.ly/NgzCJT