

TV White Space

Communications Technology

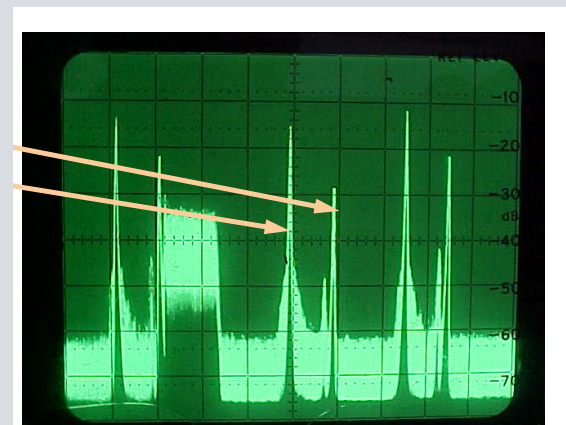
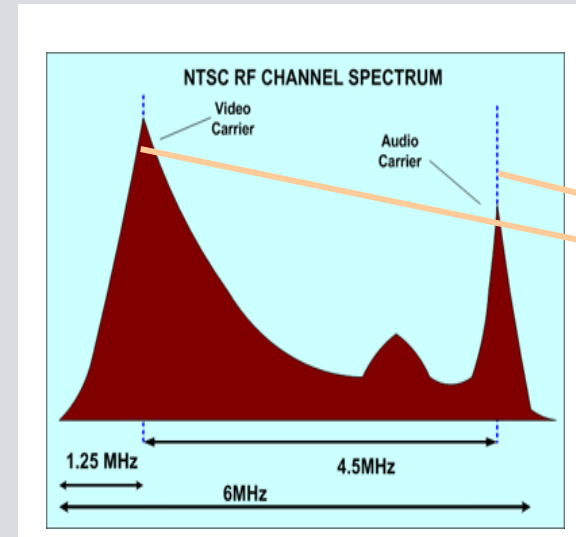
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TVWS Technology

Analog TV

What is TV White space ?

- As a start, TV frequency channels refers to the spectrum for television broadcast radio spectrum from 4 contiguous blocks of a total of 418 Mhz
 - Ch 2 – 6 :54-72 Mhz, 76-88 Mhz ($\lambda = 6$ meters)
 - Ch 7-13: 174- 216 Mhz, Ch 14-20: 470-512 Mhz
 - Ch 21 -36: 512-608 Mhz, Ch 37-51: 608-698 Mhz ($\lambda = 60$ cm)
 - Ch 52-69: 698-806 Mhz (relocated as 700 Mhz)
- The term “TV white space” relates to the same parts of, which in a given location or any given time remains unused for broadcast television. This happens when TV channels are now broadcasted via cable or fiber networks leaving them un-used or simply under-utilised. The reduced required for separation distances are offering new opportunities for TVWS
- Singapore is the only country other USA which allow “free to use” TV Whitespace. This open up huge opportunities for players to utilise them for smartgrid, remote monitoring and control and surveillance purposes. The rest that are testing for approval are UK, Canada and France

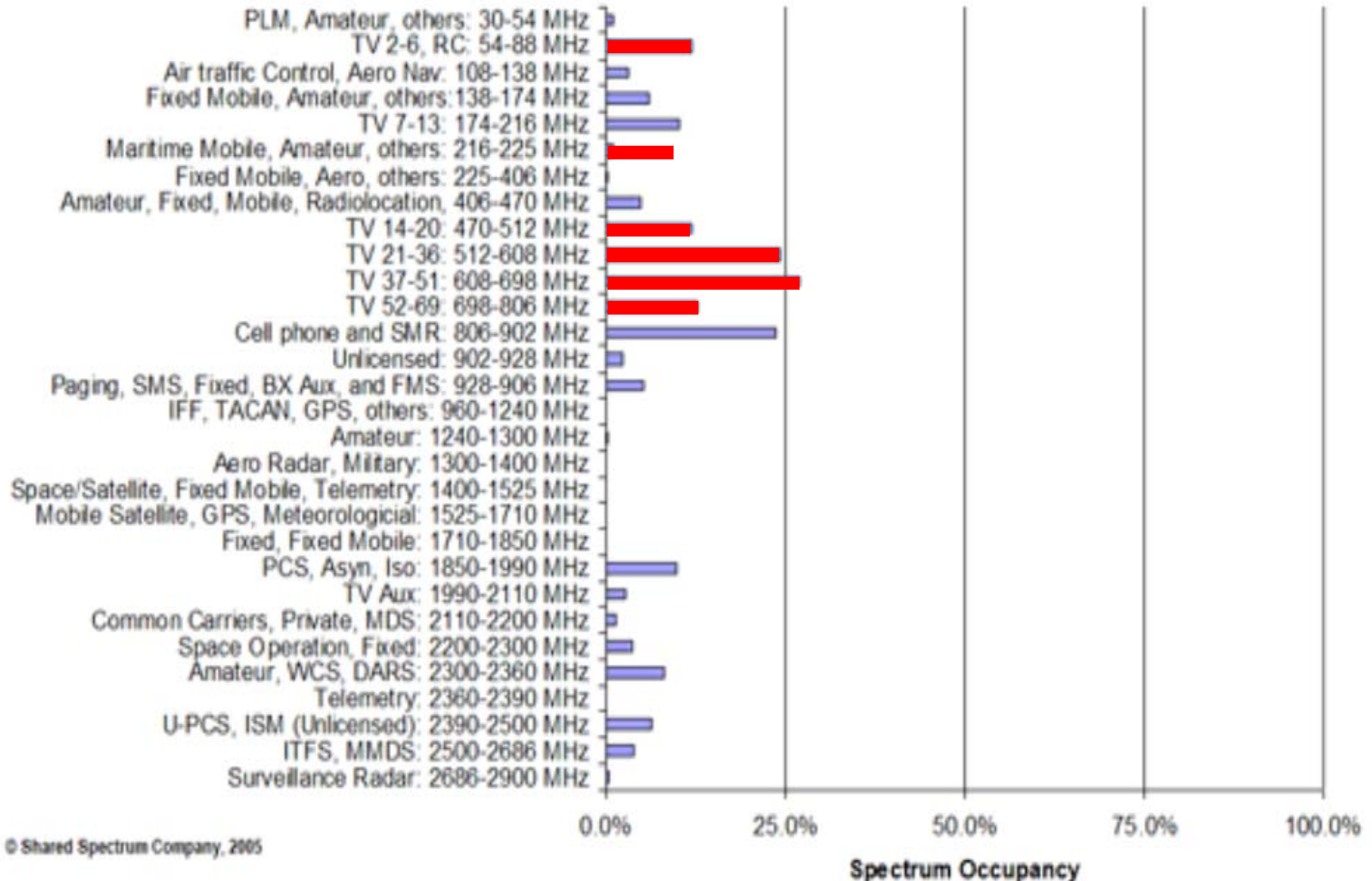


Frequency utilisation in USA

Figure 1

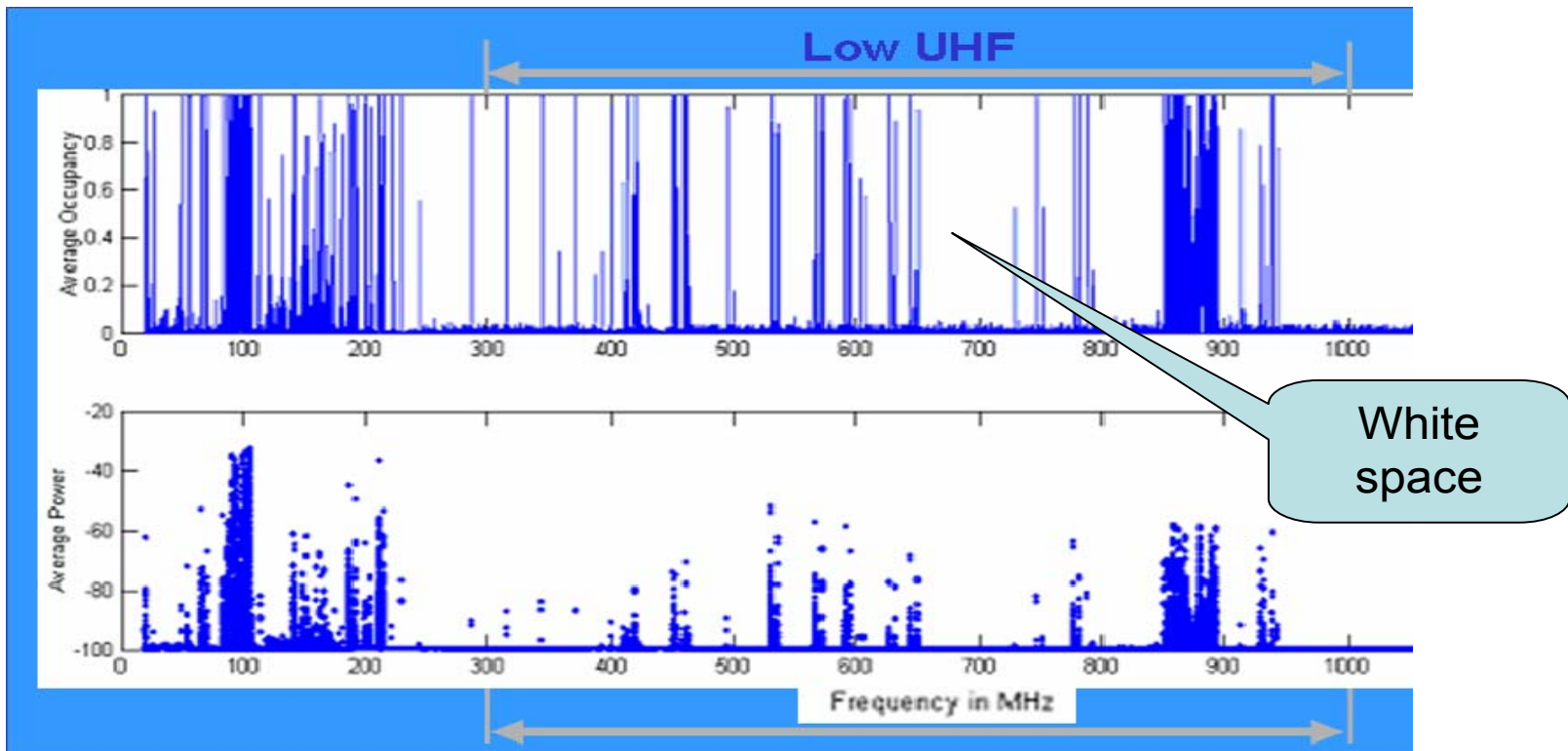
Measured Spectrum Occupancy Averaged over Six Locations

ENLARGE



What is TV Whitespace

What is TV Whitespace?



*(Test conducted in the rural sector west of Ottawa, Canada)**

US FCC Approach for TV Whitespace

- US has allocated huge amount of investments into TVWS
 - US\$7.2 billion of American Recovery & Reinvestment Act (ARRA)
 - US\$4.7 billion by NTIA BTOP (Broadband Technology Opportunity Program)
 - US\$2.5 billion added to Dept of Agriculture's RUS (Rural Utilities Service) program
 - Call to Action by US Broadband Coalition to develop a National Broadband Strategy
- Companies involved
 - Dell, Motorola, Intel and Philips over the last 4 years
 - Apple Steve Jobs greatest regret is not being able to have his own carrier as he considers the current telco too limiting to the growth of applications using the internet
 - rumoured to be Google Secret TV project and strategy behind the purchase of Motorola to gained access into handsets
 - Forming of the White Space Coalition and Wireless Innovation Alliance

TVWS Technology

- **What are the issues with using TVWS devices ?**

An issue with using white spaces in this manner is how to ensure that the white space broadcasting devices (TVBDs) operate only in the unoccupied frequencies or channels and within the limits imposed on the transmission parameters. If they fail to do so, interference may be caused to licensed users in the host countries and the neighbouring countries. To prevent this, it is necessary for the TVBDs to:

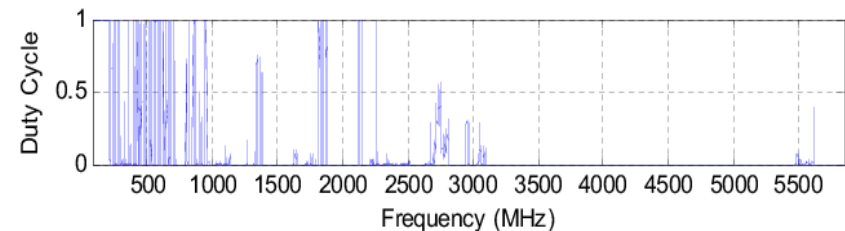
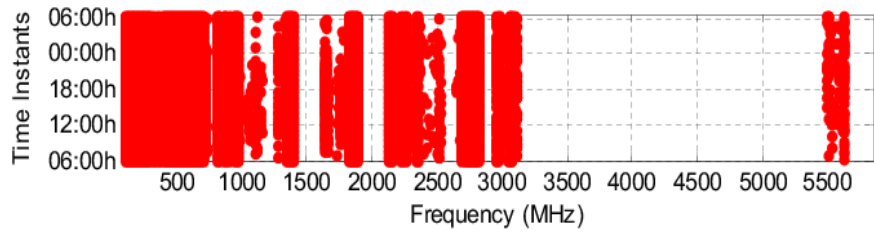
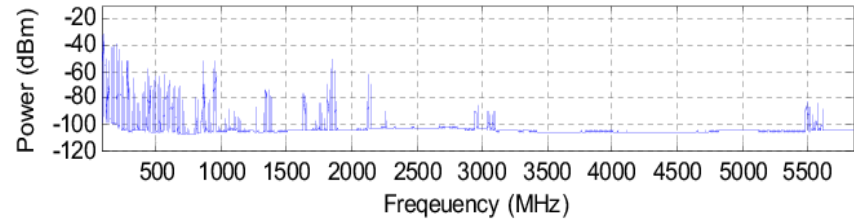
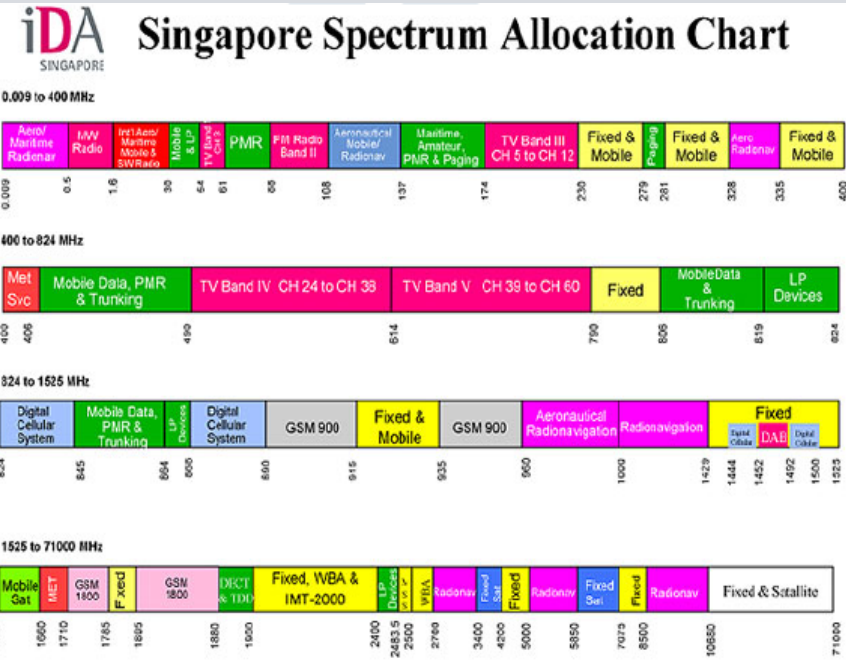
- a) determine the presence of a licensed user (TV signal); and
- b) transmit at a power level that will not cause interference to licensed services.

- We had developed the technology to use the empty slots and perform such “data slotting” without affecting the primary user
- We have completed the prototyping and ready for testing

CASE STUDY – Singapore

Spectrum allocation ~100%

Spectrum utilization ~6.5% meaning that most of the time, its free



Unused spectrum exists from ... time to time, & location to location

But this is not all! – a large chunk is block off for our neighbours – lets start with them

Regional Coordination

Indonesia TVR1

Malaysia TV2

Ch5 Ch6 Ch7 Ch8 Ch9 Ch10 Ch11 Ch12

**TV Channels
Used in SG**

**DAB Channels
Used in SG**

**Wireless MIC
Channels Used in SG**



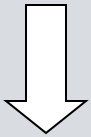
To avoid interference in TV spectrum with Malaysia and Indonesia, Singapore virtually loses 2/3 of the spectrum

Solutions?

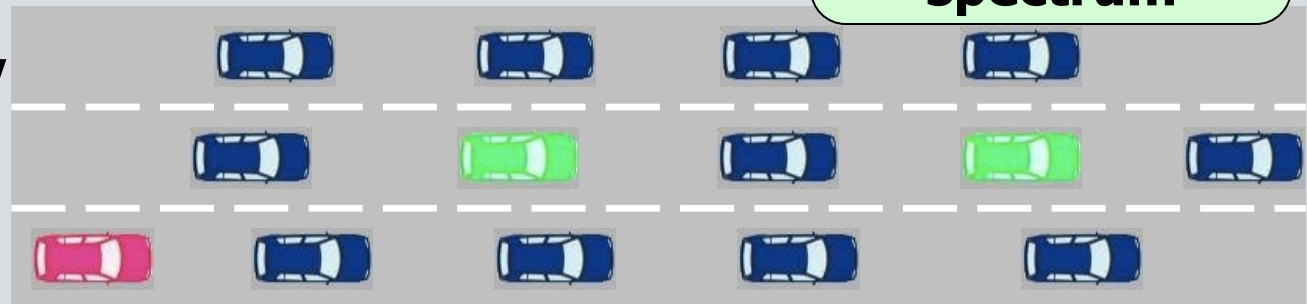
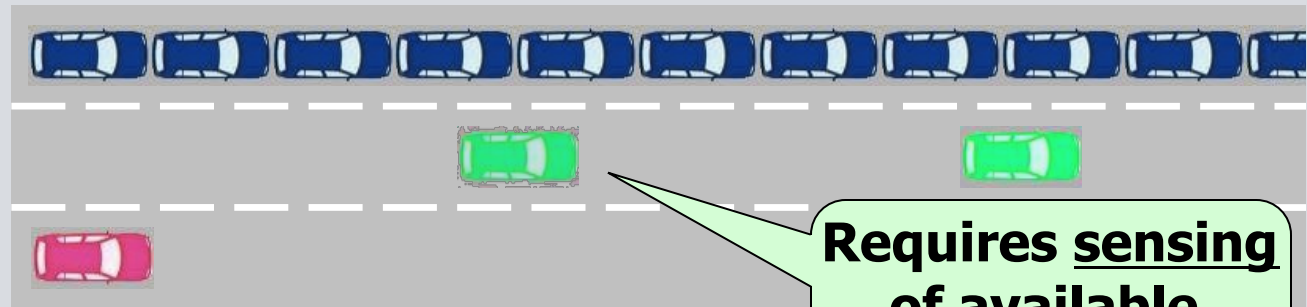
- Spectrum is wasted!
- **Cognitive radio** (CR) is a potential solution

Cognitive Radio	Car Driving
Frequency spectrum	Road
Frequency band	Lane
CR device	Car

Opportunistically use spectrum when it is idle

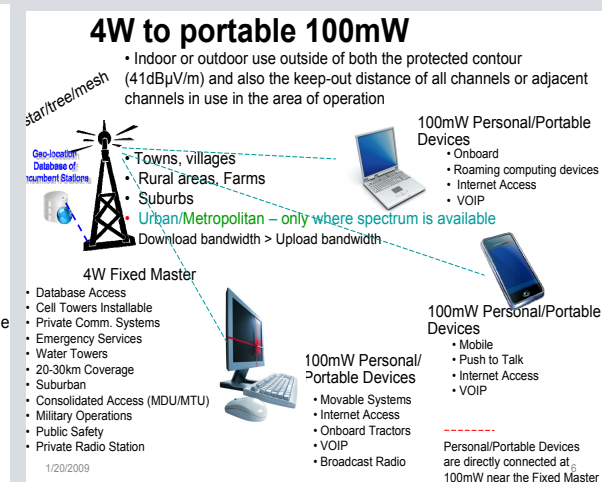
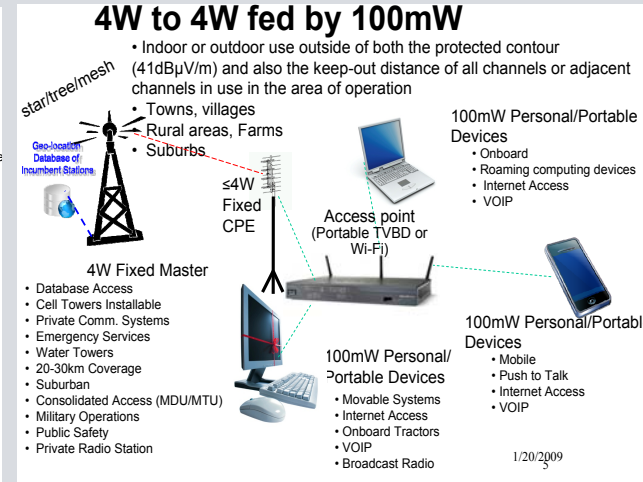
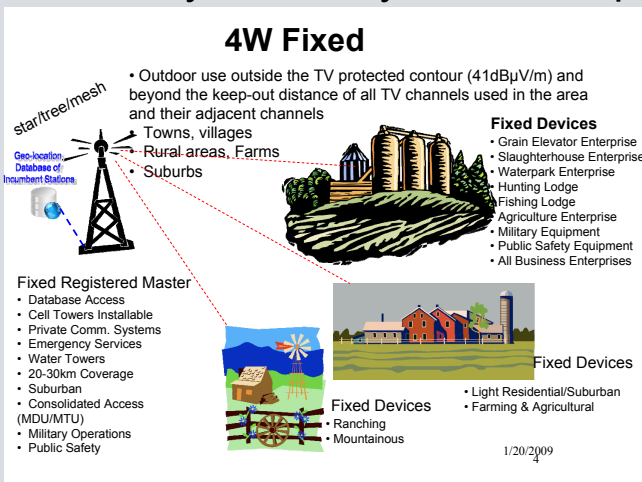


When applied on TV bands, it is called TV White Space (TVWS)



General Approach to TVWS

- Opportunity
 - Every person and device to communicate based on 802 standards
 - Insufficient spectrum exists to accommodate all possible use
 - Creative reformatting of existing spectrum and allows the exploitation of un-used and under-utilised spectrum like those at 3650-3700 Mhz spectrum
 - ability to identify available spectrum
- General Whitespace use cases
 - 4 W generally for rural/suburban
 - 4 W to 100 mW for Long Range/ Suburban with extension
 - Asymmetric (4W Downlink & 100 mW)
 - Congested Urban (Sensing Only)
 - Short Range < 50 mW

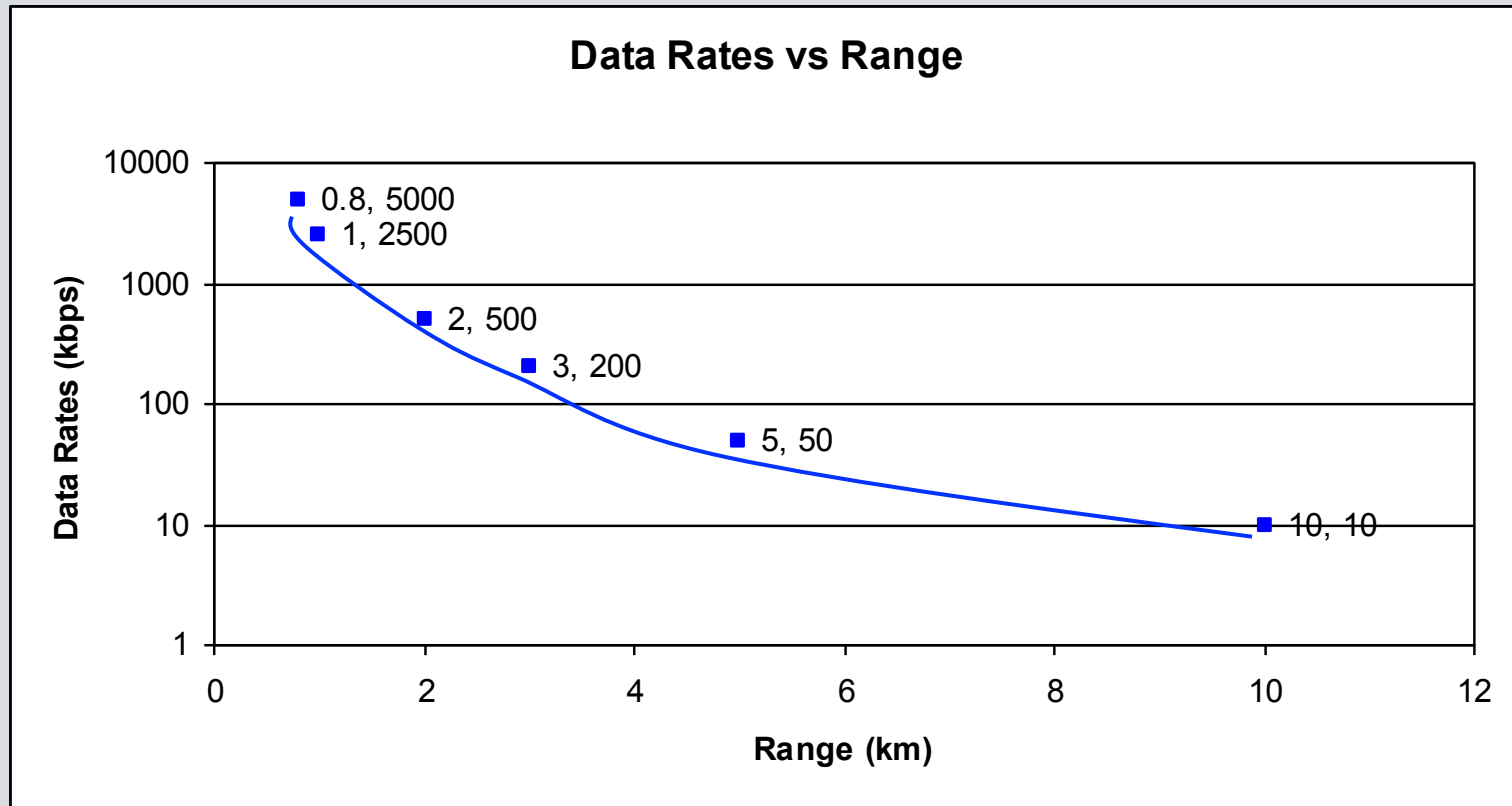


Long Range Non LOS Trial



Managed to achieve range $> 3\text{km}$
in NLOS high-rise environment
Height of antenna – 32 m , Power – 4 W

Data Rates & Range Tradeoff



- Based on path loss exponent of 2.5
- Transmission power of 4 W
- Carrier frequency of 700 MHz, can be varied and “jumped” to any unused channels and for the trial we are planning on 1.5 Mbps

Current TVWS developments

One of our applications

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Substation/Smart Metering and security Monitoring

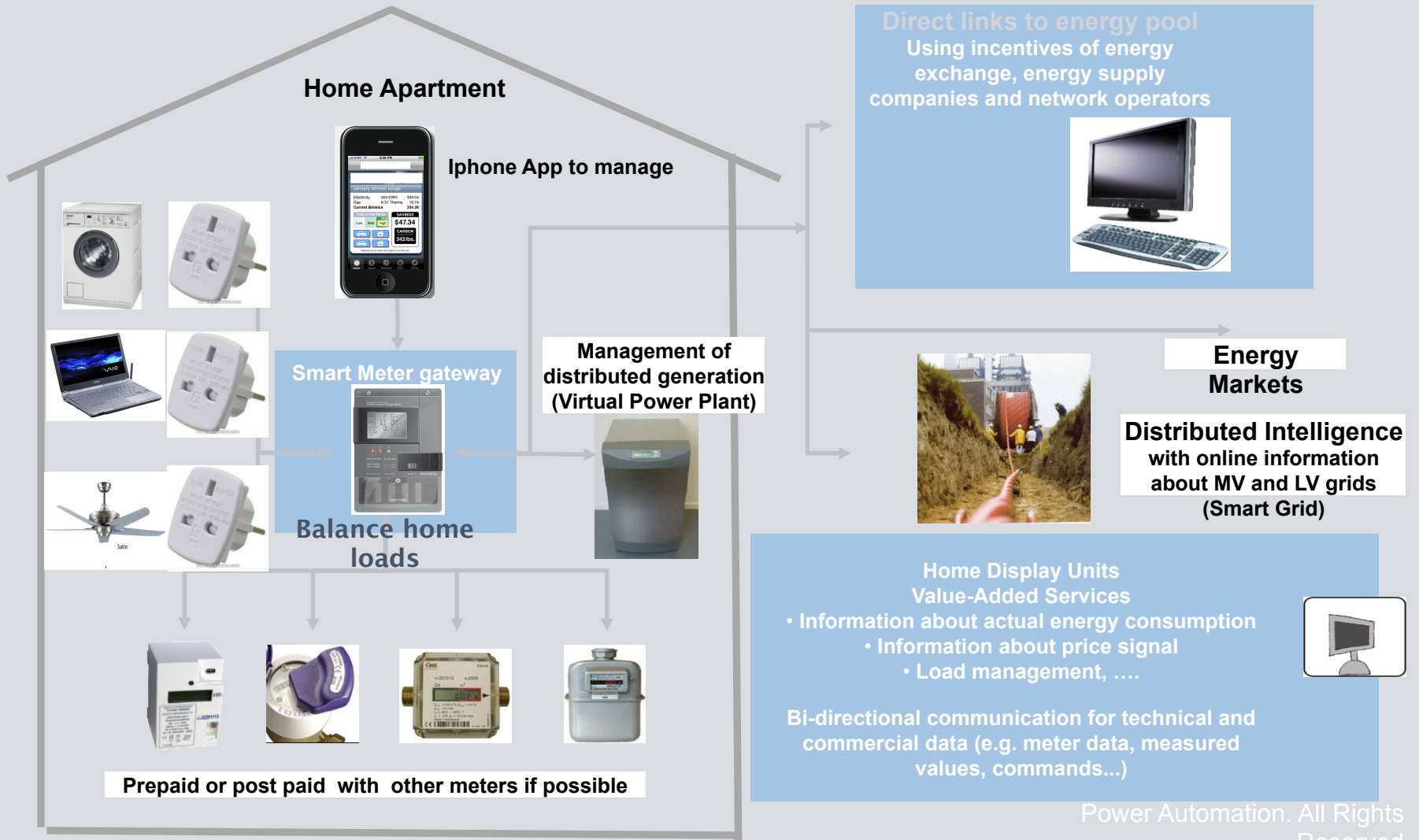
- SP Powergrid Asset Monitoring
- Substation Security Management
- Intrusion Detection/Alarm and Last Gasp Image



- Smart Metering where every meter can be a WIFI hotspot
- Smart Home payment services
- Power Status for EV and DG/ Substation Group/Grid Wide Information



Smart Home/Smart Grid Applications



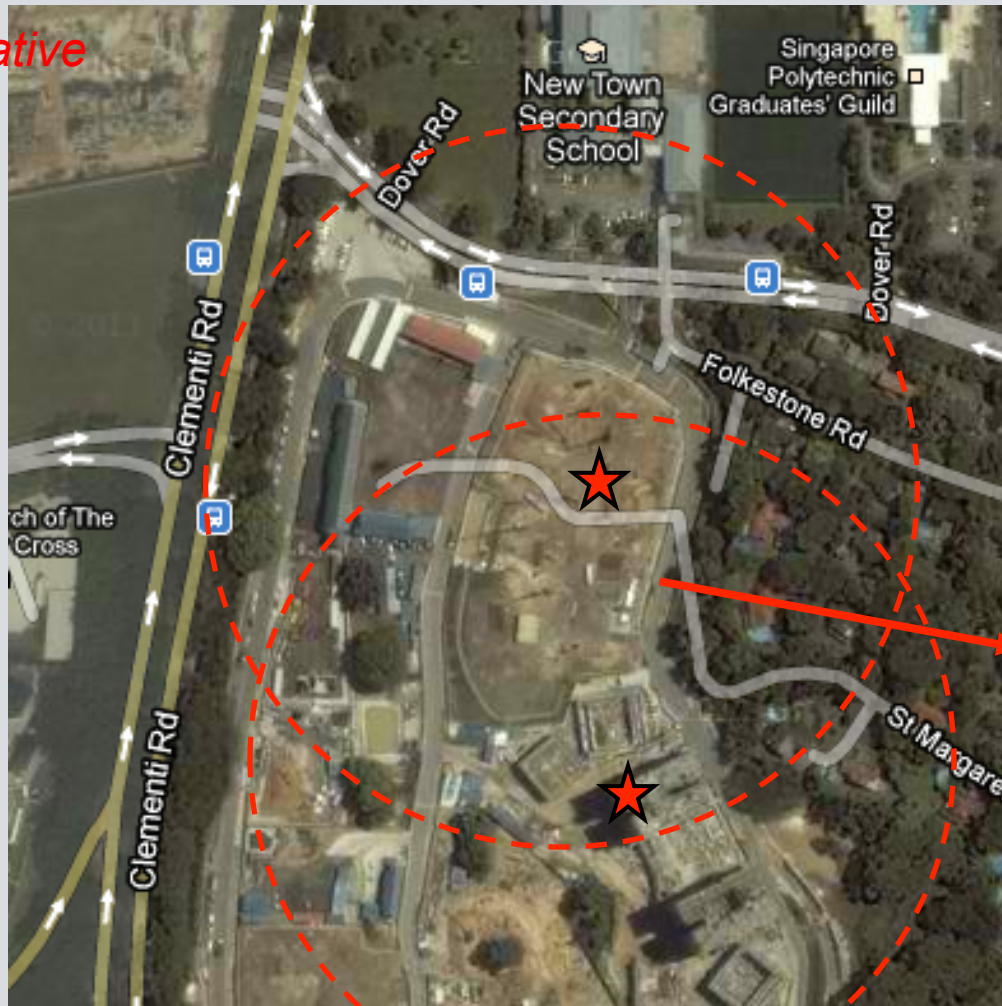
Some Current Deployments in Singapore

NUS Utown TVWS Metering Trial



TV White Space (TVWS) Trial @ NUS

Tentative

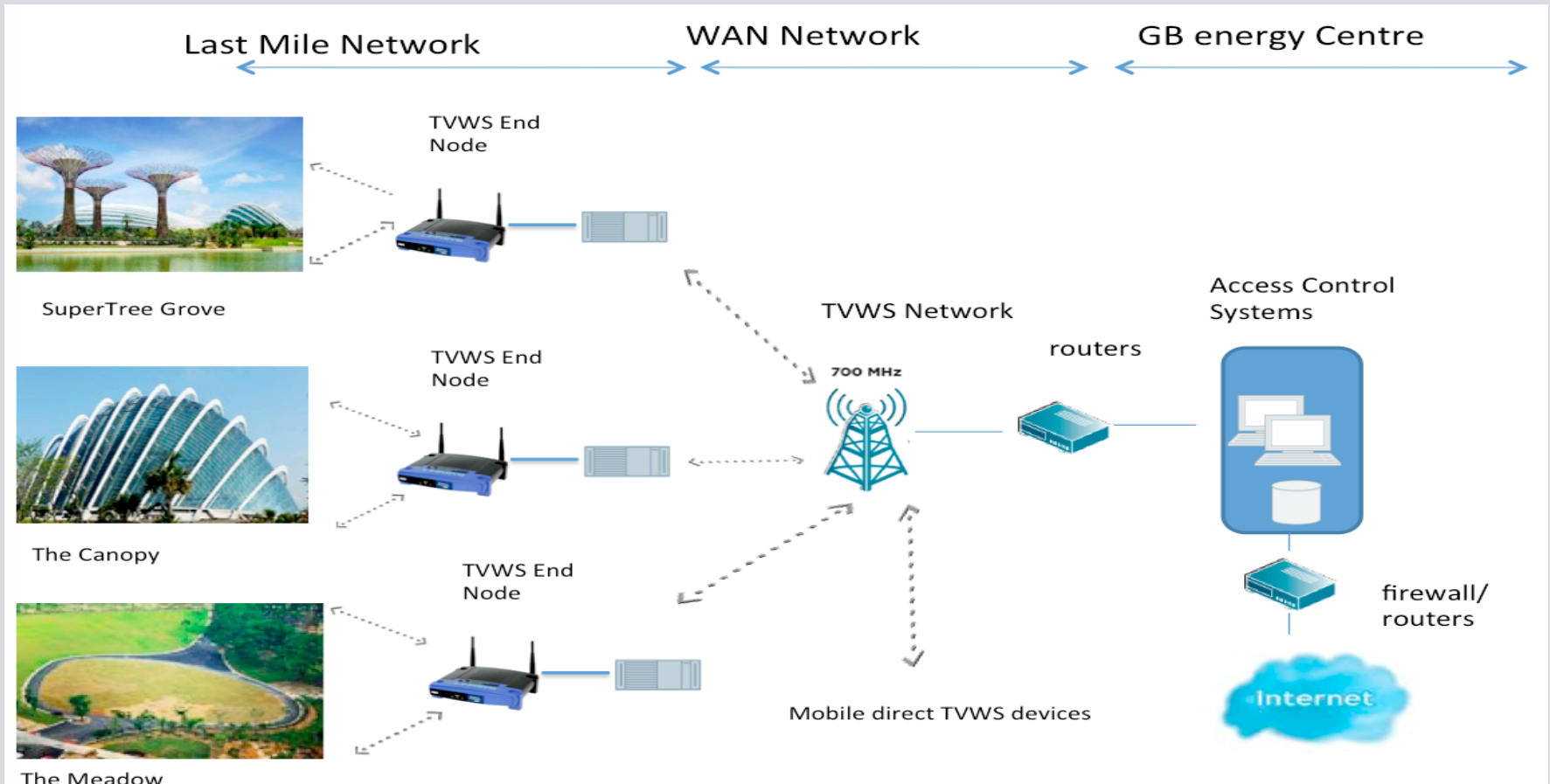


- No. of concentrators: 2 to 4
- No. of meters: up to 2000
- Frequency: UHF bands
- Range: 700-1000m
- Power:
 - 100 mW (last mile)
 - Speed to double if we set at 500 mW as approved
 - Up to 1 Watt (infra)
- Data rates: ~5 Mbps (aggregated raw rate)

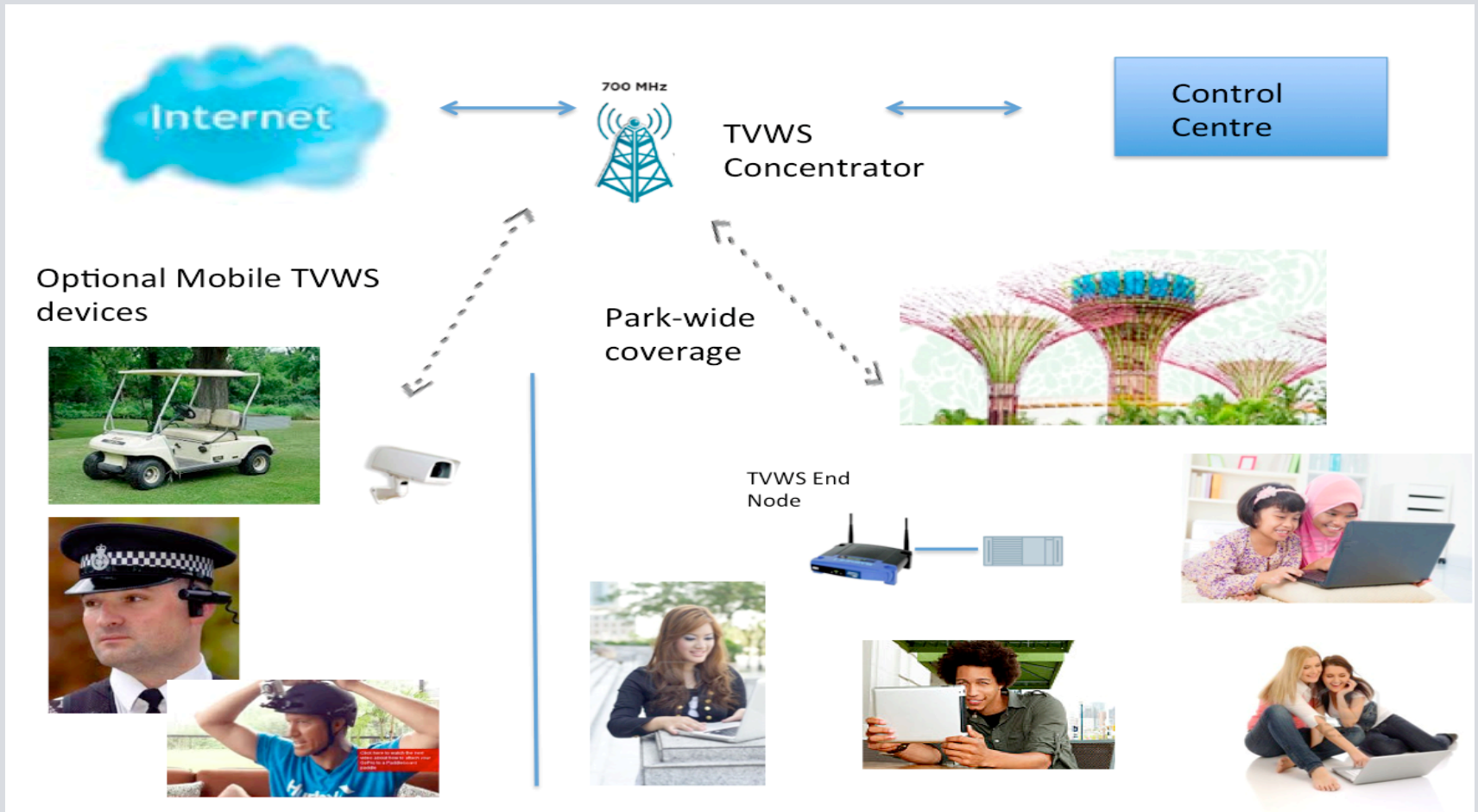
**Gardens By the Bay – TVWS/Super WiFi
Broadband connectivity for public users
to be completed by June 2013**



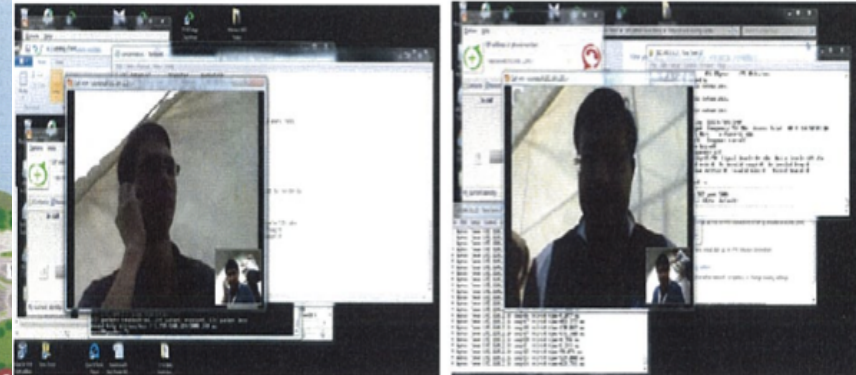
Gardens by the Bay - WAN



SuperWIFI for Internet Connectivity and Surveillance




Proof of Concept – Video conferencing



Comments:

The POC was successful. It showed Super WiFi feature and providing WiFi at greater distance without trenching and no change to the landscape.

Frederick Oh 

Name and Signature
Date: 31/1/13

Gardens by the Bay
18 Marina Gardens Drive
Singapore 018953

No.	Venue of secondary transmission device	Video Clarity of 1 – 5 (1 as poor, 5 as good)	Voice Clarity of 1 - 5 (1 as poor, 5 as good)
1	The Meadow	5	5

Smart City – Punggol Town

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Smart City Deployment – HDB Punggol Town/ Yuhua Town



Vision

- to use TVWS is to breach longer distances to provide Secure Private wireless connectivity – Lower costs

Type of M2M Applications and devices for greenprint

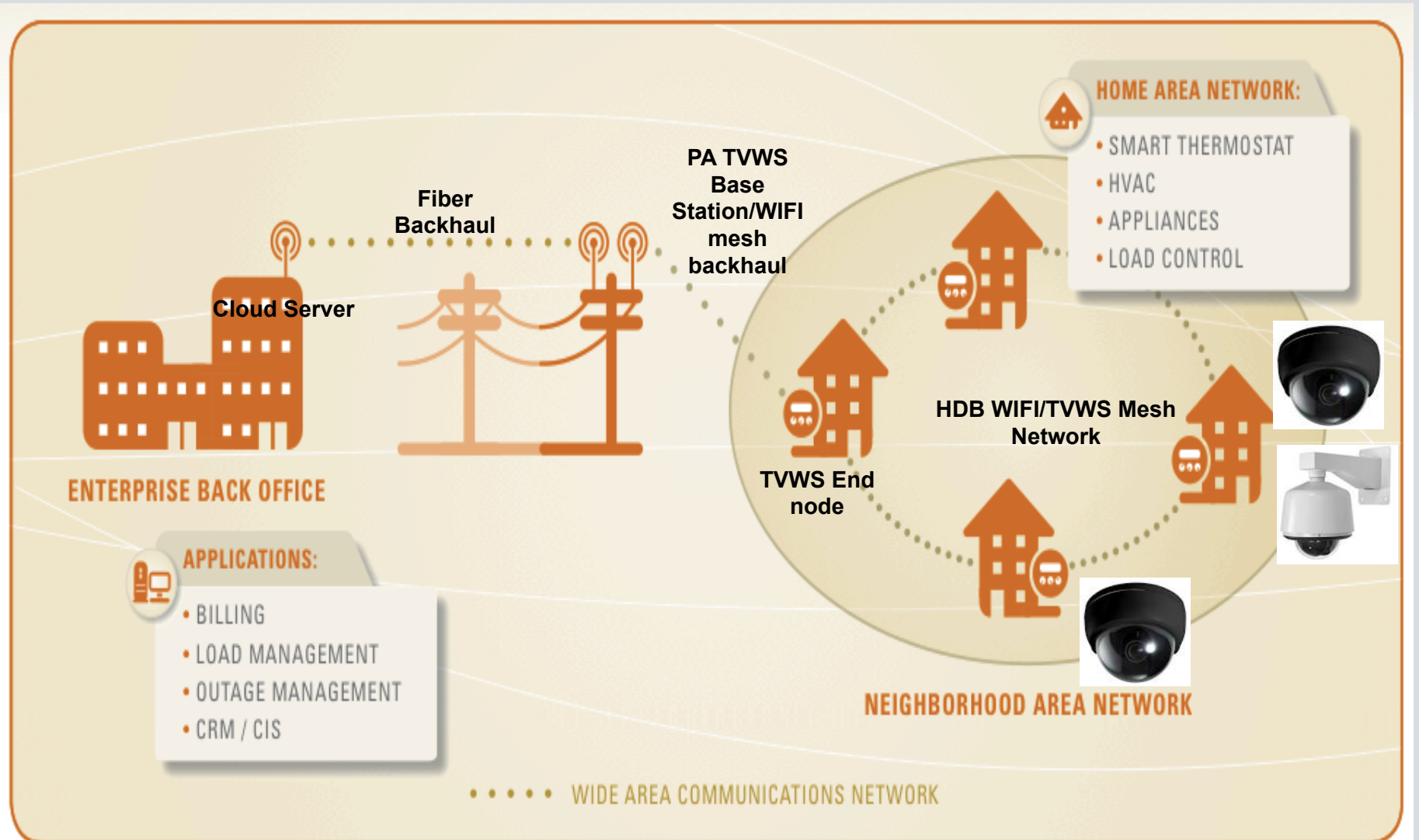
- Energy Metering using Power meters installed at HDB switchrooms
- Metering of PV panels
- Streetlight control

Potential Applications

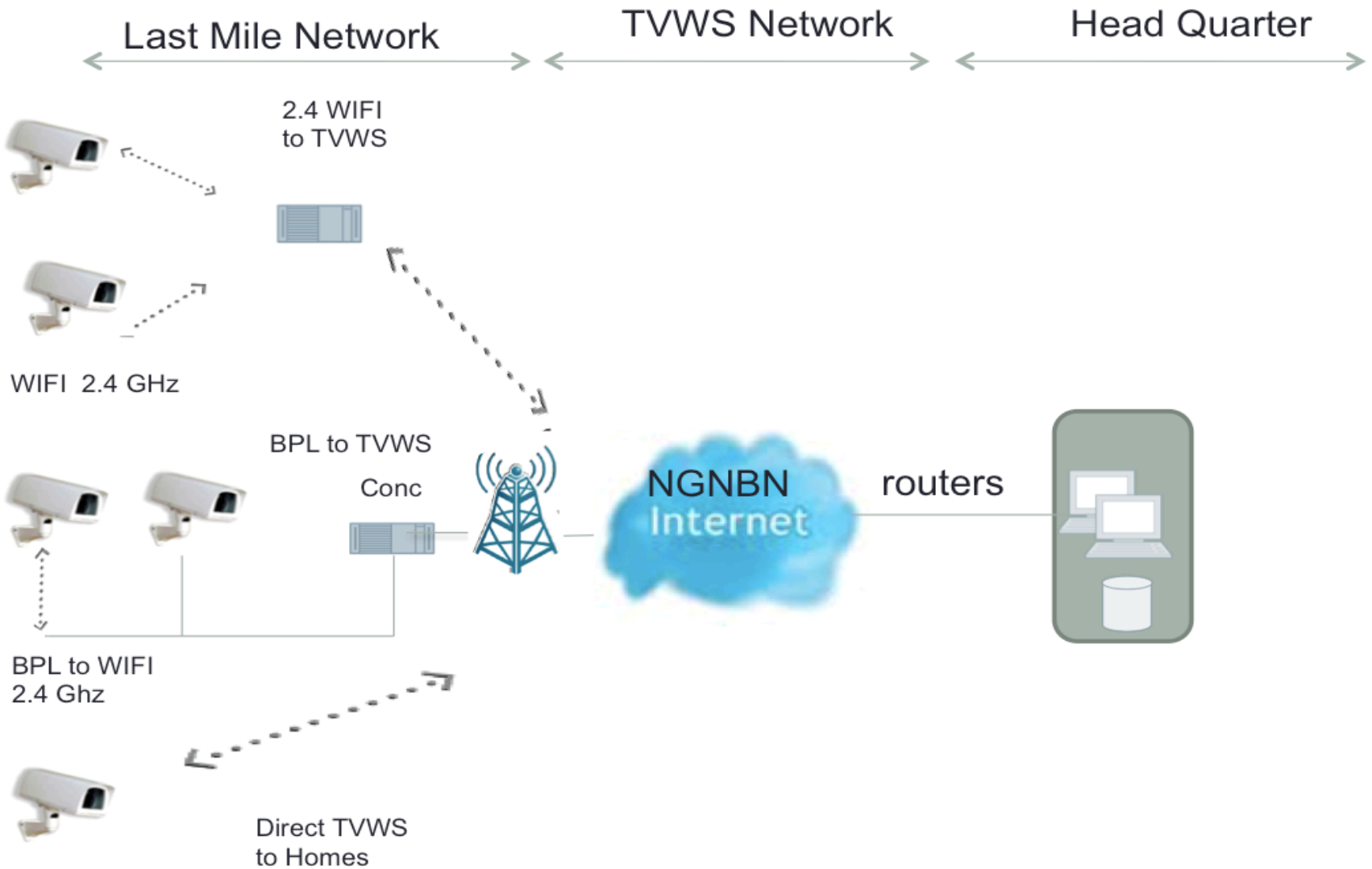
- Rooftop and illegal Carpark/Activities using Video cameras and encoders
- Environment Management - Temperature sensors
- Condition Monitoring/Smart Maintenance of equipment - Lift Monitoring/Rubbish/Littering surveillance/Management
- Lighting on/off/dimming control

Town Specs: 5 sq km town
100 blocks
2000 households

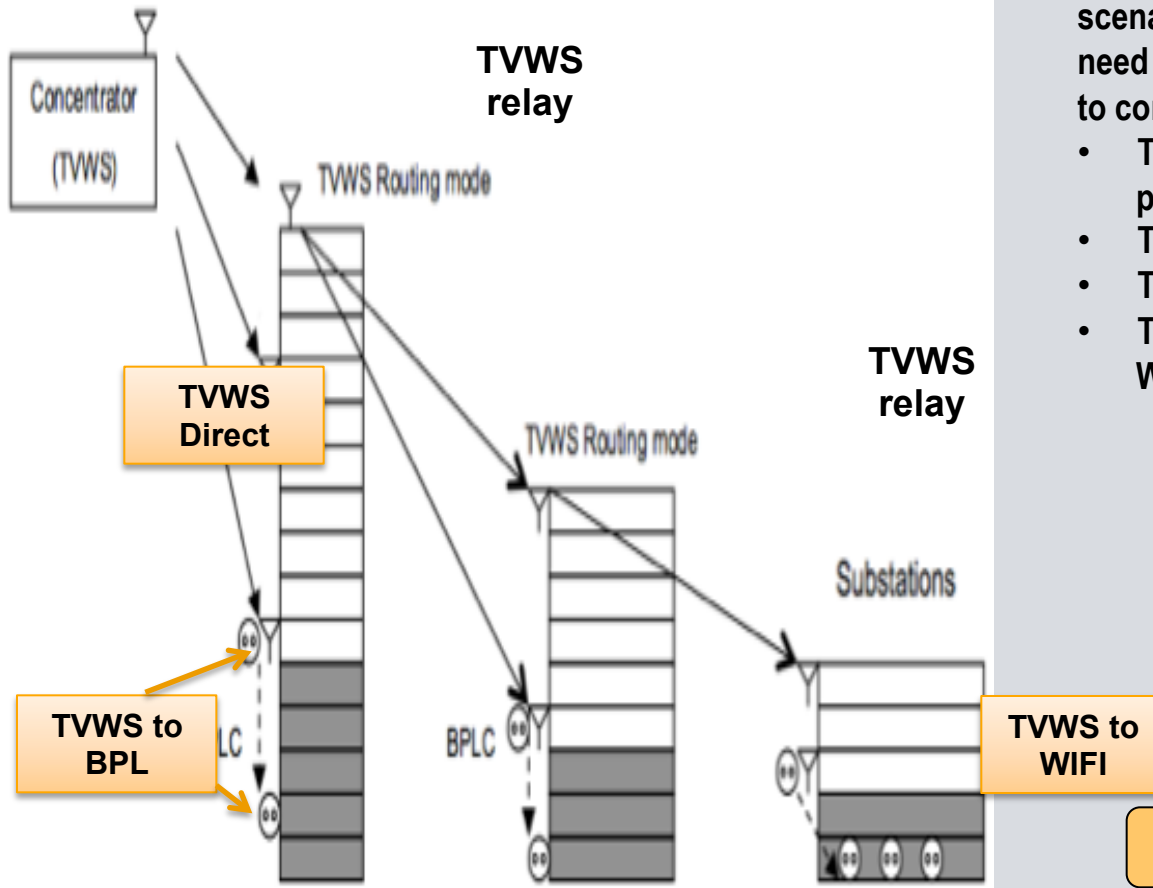
Backhaul Topology- from backhaul to Neighborhood Network (NN)



Network Architecture



TVWS to BPL/WIFI Deployment Network



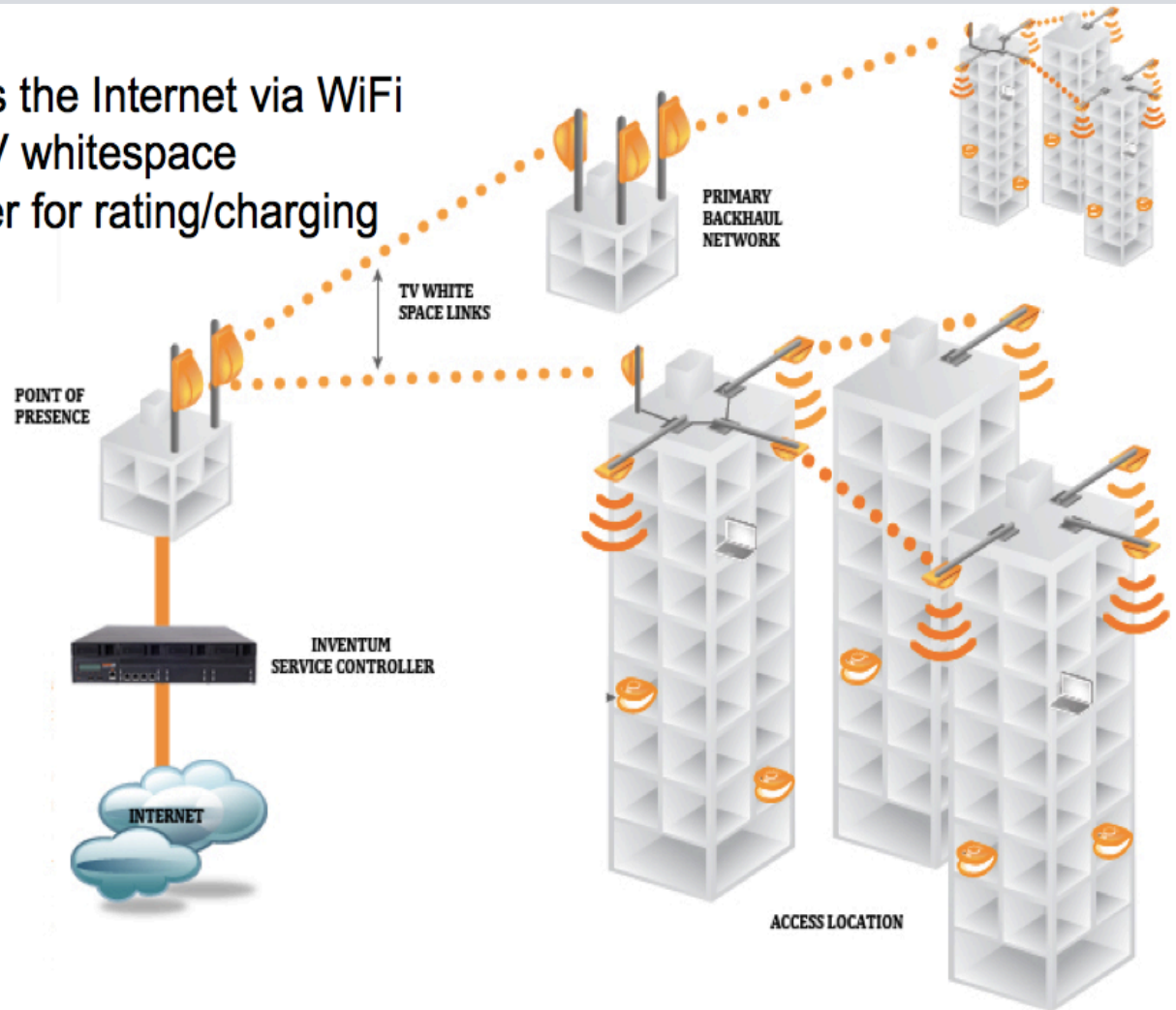
TVWS can be deployed in different scenarios and note that at the end we need to put as ethernet or WIFI for users to connect:-

- TVWS Direct to Households – when possible
- TVWS to BPL
- TVWS to 2.4 Ghz WIFI
- TVWS to BPL and BPL to 2.4 Ghz WIFI

We can also extend WIFI using WIFI extender

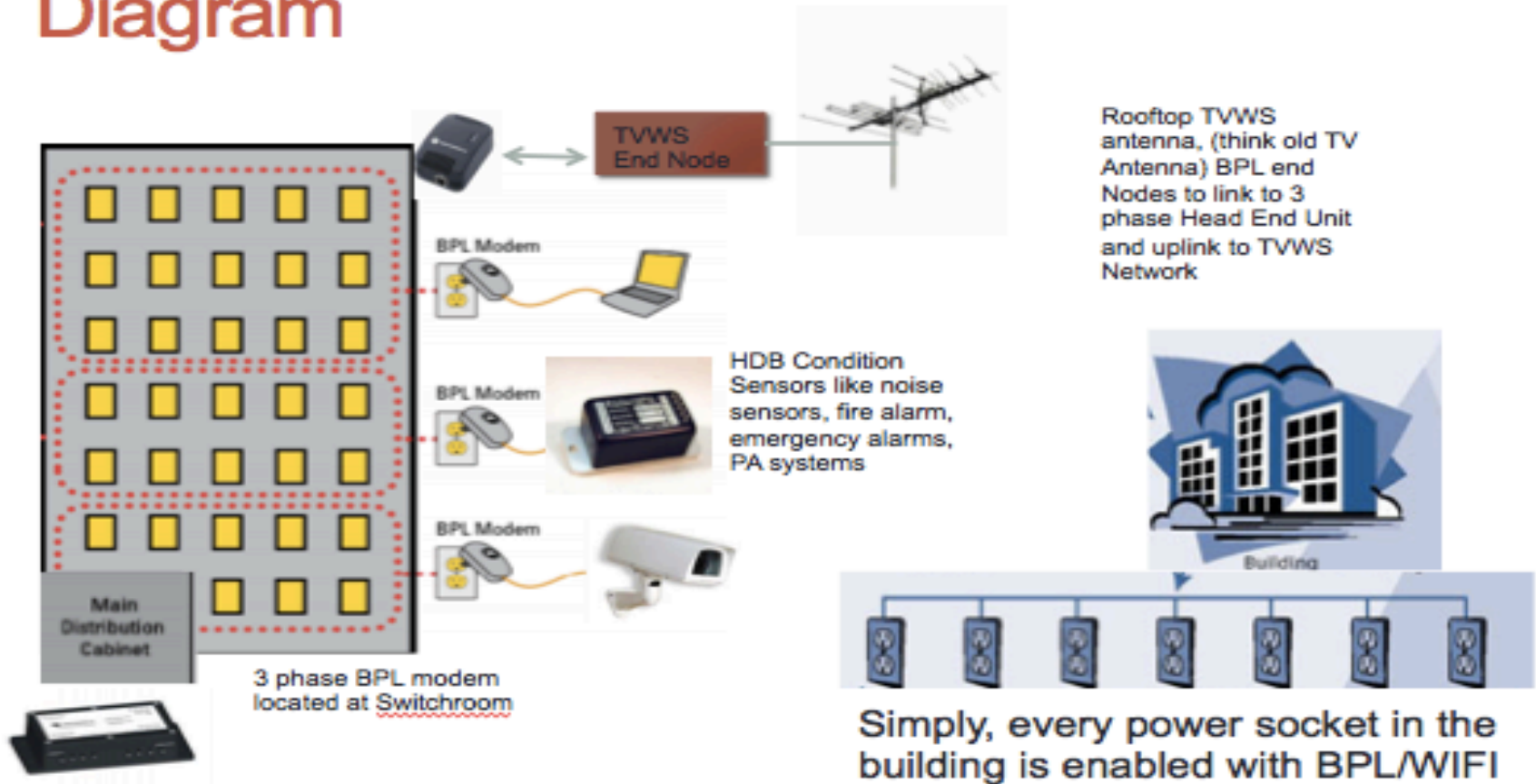
HDB @ WIFI

- Users will access the Internet via WiFi
- Backhaul with TV whitespace
- Service Controller for rating/charging
- Fair Use Policy



In Building Connection

In Building BPL/WIFI Connection Diagram



Sentosa island Wide Wireless Surveillance and WIFI

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Sentosa island wireless surveillance and WiFi coverage plan

Optional Extension Palawan Beach Coverage



HQ-to-Merlion Link

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Last Mile Network

TVWS WAN Network

Sentosa HQ



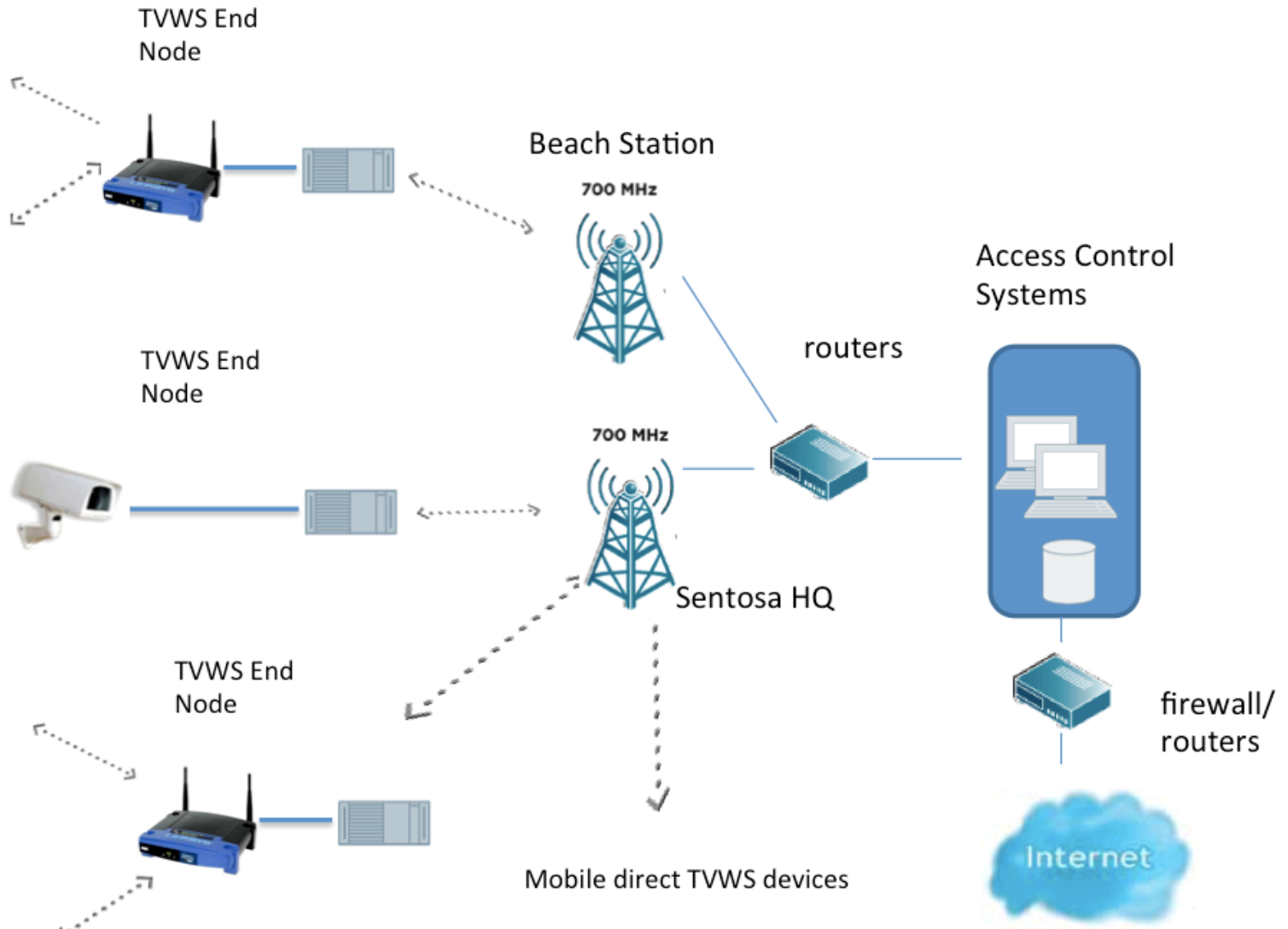
1 Site @ Palawan Beach



1 Set of IP Camera @ Merlion Plaza



Sentosa Golf Club (optional)



Shell Bukom – Permitting and Wireless Fencing

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Permitting for Shell Bukom



TVWS Base Station

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Wireless Alarming

- Location by GPS+TVWS end alarms – IP alarms
- Once installed, clustering and zoning by backend settings
- Logic of alarm from timing control, frequency of alarms and triggers
 - Suitable for smoke alarms, emergency, heat and even movement on certain timings
 - Alarms broadcast after trigger can be general or specific to groups
 - Remote control/cancellation
 - Integrate to video feed
 - Enforcement needs



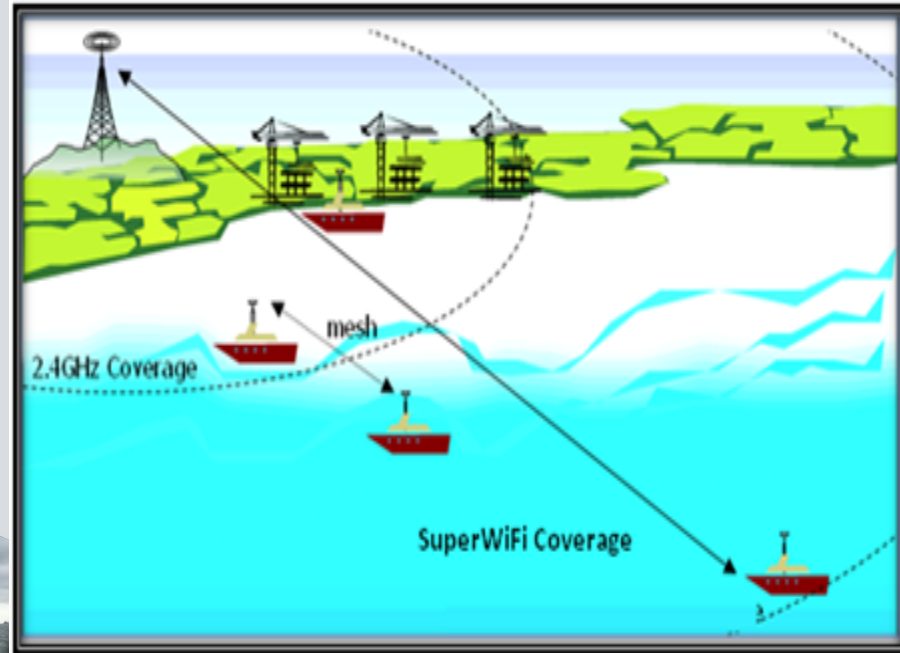
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PSA – Port and Offshore Connectivity

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Over the Waters

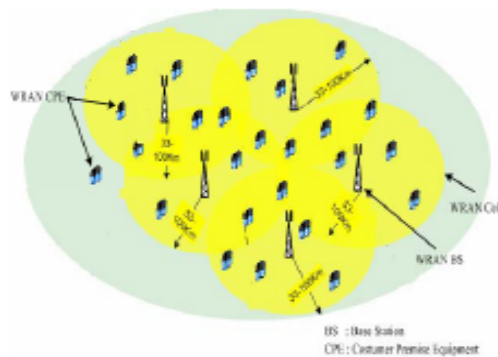
Police Coast Guard Border Connectivity Plan



Types of TVWS Applications

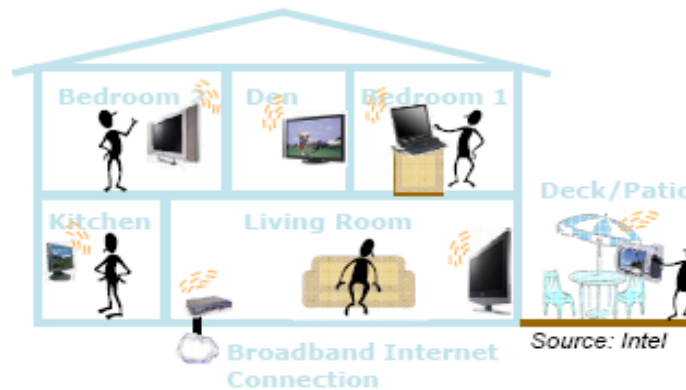
Potential TV WS Applications

WRAN (IEEE 802.22)



High Power Fixed

In-Home MM Distribution



Neighborhood Networks



Low Power Portable

Tele-Health
(Assisted Living & Elderly Care)



Fixed and/or Portable

Home Automation
& Control



Low Power Portable

Telephony



Low Power Portable

Comparisons between 3G/GPRS to TV White Space

Factors	3G HSPA	TVWS
Price (\$/month)	53.90	0
Max. speed ¹ (Mbps)	4.8 (DL), 1.3 (UL) ²	13.5
Max speed at cell edge (Mbps)	0.6	1.5
Max number of simultaneous connections (assume 100 kbps for Smartgrid applications like load shedding)	6	18
Number of simultaneous 5 MHz frequency channels (max)	1	10 ³
Max number of meters/devices per Access point at one location	600	6000

Notes:

¹Based on Singtel: <http://home.singtel.com/bbmobile/>

²Uplink (UL) speed is estimated based on downlink speed. Average trueput from 3G 7.2 Mbps are really not achievable and really less than 300 kbps at most situations . GPRS is only 80 kbps at best.

³Based on IDA's current TVWS guideline

⁴The actual numbers should be higher as it is unlikely that all devices will be at cell edge

Conclusions

TVWS has range and penetration benefits compared to other technologies

TVWS is moving from concept to commercialization

Various aspects such as regulations, technologies, applications, end users are in place

TVWS is gaining momentum worldwide

We are looking forward to more innovative use of TVWS

Q&A