

# TV White Space:

## Trends and Opportunities for Smart City development



*An A\*STAR spin-off company*

*Connecting 3B people and 50B devices thru' dynamic spectrum sharing technique*

<http://www.whizpace.com>

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# Outline

- Smart City Concept
- Singapore as Smart Nation
- Issues with current spectrum allocation
- TV White Space (TVWS)
- TVWS as Enabler for Smart City
- Summary

# Mega-trends that lead to Smart City

Quote from IEEE: As world urbanization continues to grow and the total **population expected to double by 2050**, there exists an increased demand for intelligent, sustainable environments that reduce environmental impact and offer citizens a high quality life. A smart city brings together technology, government and society to enable the following characteristics:

a smart **economy**

smart **mobility**

a smart **environment**

smart **people**

smart **living**

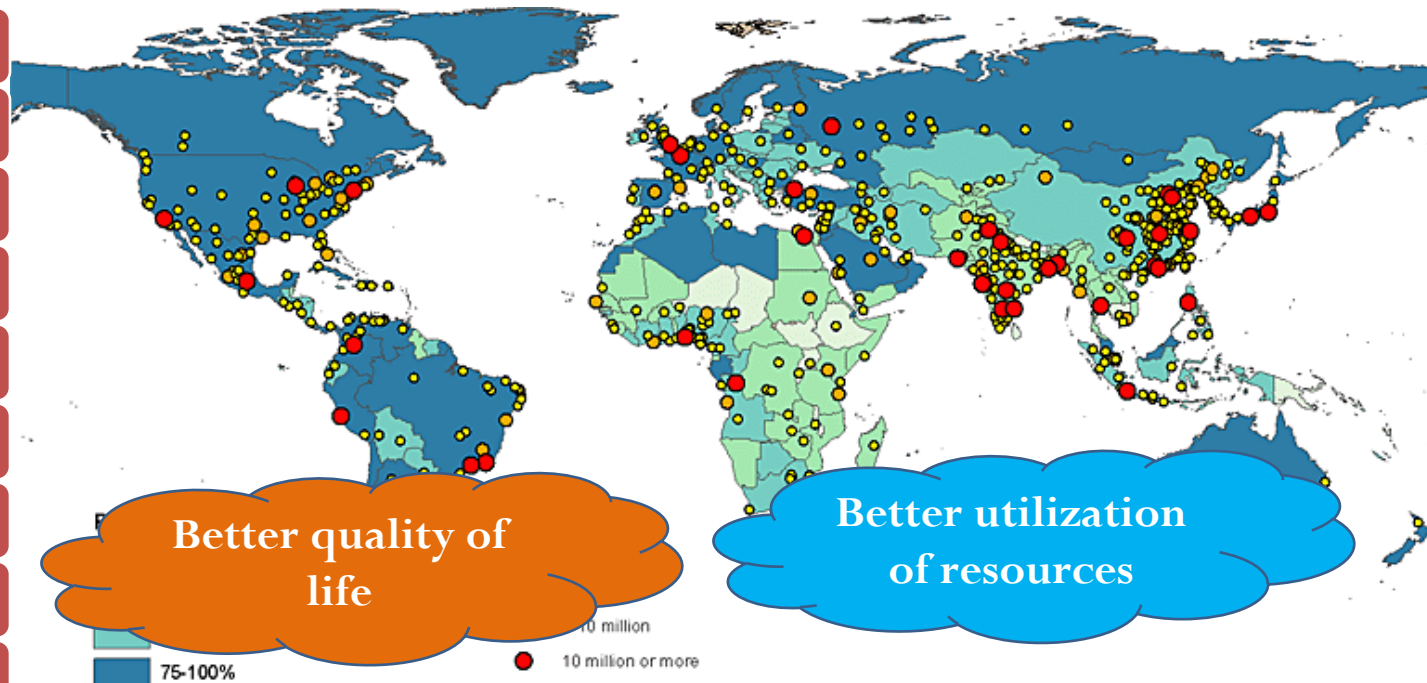
smart **governance**

smart **buildings**

smart **energy**

smart **communications**

smart **networks**



Percentage of urban population and agglomerations by class size, 2025

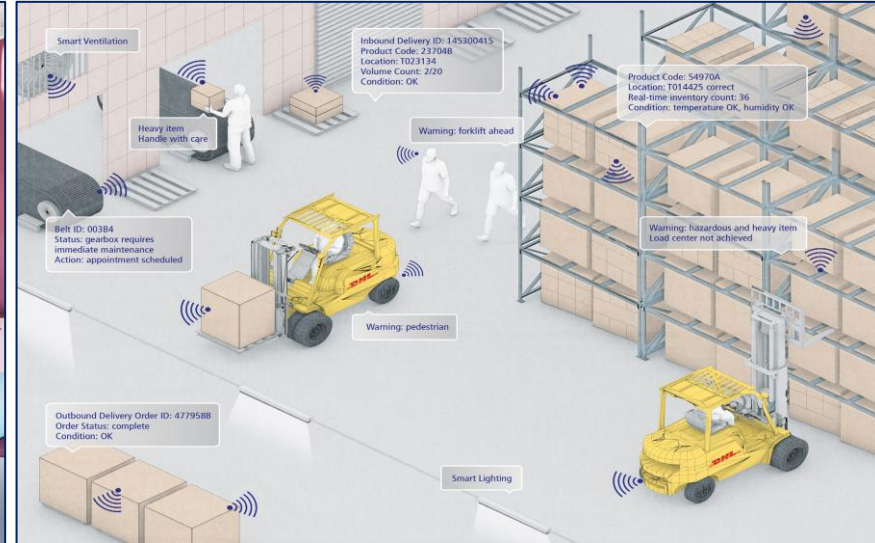
Source: United Nation

- By 2050, half the world will move into cities. Digital revolution is redefining the economic and social structure of the world
- Numerous cities aspiring to become smart cities – digitally connected cities that break down the siloes between governments, businesses and citizens to enable better quality of life.

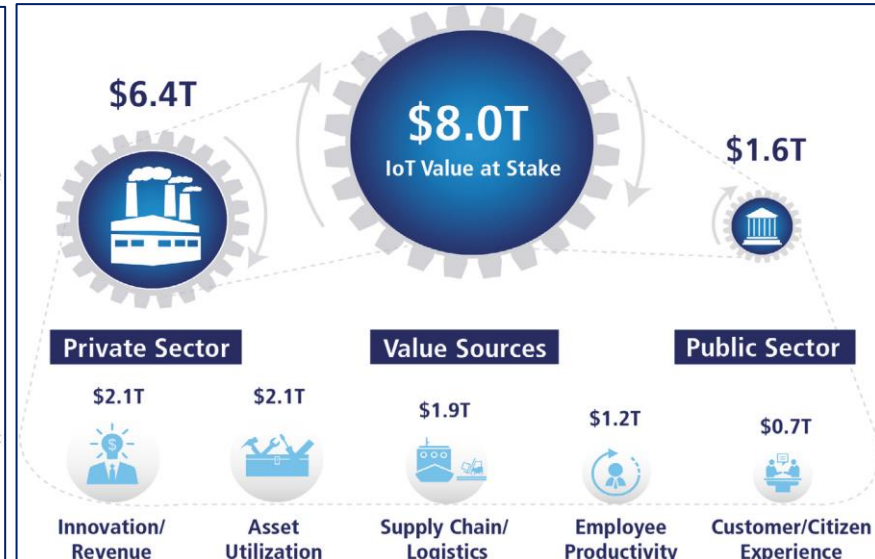
# Features of smart city/ IoT/ IoE



The Connected Home and Consumer



IoT in Logistics Industry



5 IoE, the Networked Connection of People, Process, Data, and Things

IoT Value at Stake

Source: DHL Trend Research | Cisco Consulting Services

## What are the GLOBAL CHALLENGES?



### Urban Density

Two-thirds of the world will live in cities by 2050.



### Ageing Population

The world is ageing fast. By 2050, more than 2 billion people will be over 60.



### Healthcare

By 2025, there will be 8 billion people, 800 million of whom will be over 65 with high health needs.



### Mobility

People are moving more into congested centres, with urban travel to triple by 2050. Traffic congestion could bring cities to a standstill.



### Energy Sustainability

Global demand for energy will rise by up to 37% by 2035.

## Why START UP in Singapore?

World's most tightly packed entrepreneurial ecosystem<sup>6</sup>

Government data sets open for global innovation

US\$41 billion government investment in R&D<sup>7</sup>

World-ranked Universities

US\$24 billion funding pool<sup>8</sup>

7,000 MNCs

Use Singapore as a **Living Lab** for new technologies

Enjoy the **world's easiest place to do business**<sup>9</sup> – register a company online in 15 minutes

Leverage the **world's fastest broadband**<sup>10</sup> – nationwide ultra-high speed 1Gbps access

Access a skilled ICT workforce, **more than 150,000 strong**

Reach **600 million people** in the rest of S.E. Asia



# Smart Nation

S I N G A P O R E

Many Smart Ideas • One Smart Nation

# Possibilities of Smart Nation

## HEALTHCARE

Tele-monitoring using wearable devices, assistive technologies for the disabled and elderly



## INTEGRATED PUBLIC SERVICES

Unified mobile app for feedback and incident reporting



## INTEGRATED CITY PLANNING

Analytics-driven provisioning of facilities and services



## URBAN LIVING

Smart home technologies to reduce utility bills, environmental monitoring for outdoor public spaces



## URBAN MOBILITY

Demand-responsive public transport system, self-driving vehicles



## SAFETY AND SECURITY

Real-time video surveillance and analytics for improved public safety, early flood warning, faster emergency response



# Some of the smart solutions in Singapore



Next generation port



Smartbins installed at parks



iCollect self-service kiosk for Passports etc.

# Some of the smart solutions in Singapore



Automatic Vehicle

- Solve the challenge of the last **500 meters**
- Take the commuter from doorstep to the underground station or bus interchange
- Operator-less lift to **driverless cars**

- Address manpower challenges and **productivity** issues in **manufacturing**
- **Waiters** to serve food and beverages in restaurants



Robots

## Meet the future of street lighting!



- **Solar** powered lamps
- **WiFi AP**
- Equipped with **cameras and environmental sensors**
- Provide **video feed, street lighting** and other traffic related information
- **EV Charging & Adaptive lighting**

Smart Street lights

- **Wearables** moving into business and factory environment
- **Alzheimer's** and wanders off
- **IoT machines** are feeding **live data** into the enterprise
- **Glasses** are high performing way to do it



Wearables





# Smart Nation S I N G A P O R E

Many Smart Ideas • One Smart Nation



**Urban  
Mobility**



**Environment**



**District  
Management**



**Healthcare**



**Logistics**



**Manufacturing**



**Energy &  
Sustainability**



**Retail &  
Advertising**

*Supporting Ecosystem*



**Build Industry**



**Develop IP**



**Build Manpower**

## Smart Nation Platform

Smart Nation Operating System

Communication & Sensor Networks

# Smart City: Pervasive Connectivity



## Wireless



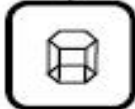
**n**∞  
Next Gen  
Nationwide  
Broadband  
Network

**Nationwide  
Broadband Network**  
High-Speed Fibre



**Wireless  
@SG**

**Wireless@SG**  
Wireless Broadband for  
Public Access



**SMARTNATION**  
PLATFORM

**Smart Nation Platform**  
Extending pervasive  
connectivity for sensors,  
open data and co-creation  
of new services



**HETNET**  
HETEROGENEOUS  
NETWORK

**HetNet**  
Seamless Roaming  
between networks

*Source: IDA Singapore*

**Spectrum scarcity may hinder Smart City Development!!**

# It is not only coverage, but capacity too

## What about network congestion?!?

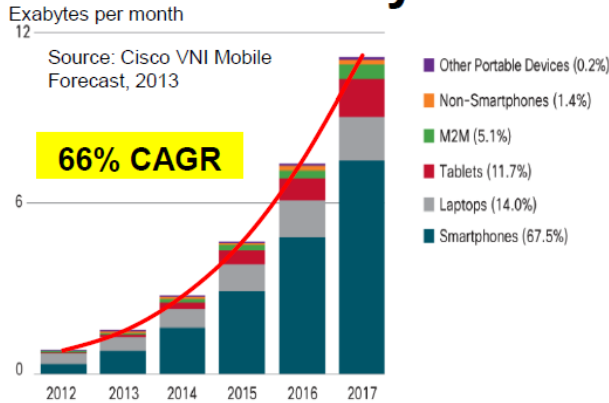
Shopping Malls	Completion Date ✓ = completed	Download Speed (before enhancement → after enhancement)
Plaza Singapura	23 October 2012 ✓	2.74 Mbps → 6.35 Mbps
Causeway Point	23 October 2012 ✓	1.67 Mbps → 4.20 Mbps
Singapore EXPO Hall 1 to 6	29 October 2012 ✓	0.65 Mbps → 1.67 Mbps
Wisma Atria Shopping Centre	30 November 2012 ✓	1.65 Mbps → 4.44 Mbps
nex	30 November 2012 ✓	0.43 Mbps → 2.41 Mbps
Jurong Point Shopping Centre	30 November 2012 ✓	1.35 Mbps → 2.64 Mbps
Bugis Junction	30 November 2012 ✓	0.34 Mbps → 3.42 Mbps
Northpoint Shopping Centre	12 December 2012 ✓	1.08 Mbps → 2.06 Mbps
VivoCity	13 December 2012 ✓	0.83 Mbps → 2.0 Mbps
ION Orchard	19 December 2012 ✓	1.67 Mbps → 2.45 Mbps
AMK Hub	21 December 2012 ✓	0.52 Mbps → 2.09 Mbps
Tampines Mall	28 December 2012 ✓	0.06 Mbps → 0.94 Mbps
Junction 8 Shopping Centre	9 January 2013 ✓	0.96 Mbps → 1.90 Mbps
Parkway Parade	January 2013 ✓	0.33 Mbps → 4.31 Mbps
313@Somerset	February 2013 ✓	1.03 Mbps → 4.94 Mbps
Far East Plaza	February 2013 ✓	2.21 Mbps → 5.79 Mbps
Upp Cross Point	April 2013 ✓	1.55 Mbps → 2.96 Mbps
Marina Bay Sands	June 2013 ✓	

**Download still bad,  
upload can be worse even with upgrade!**

**BUT, Smart City needs uplink!**

# Exponential growth in wireless resulted in Spectrum Crunch

## Today



Demand driven primarily by smartphones & tablets

## Future

### IoT connected devices explosion

212BB Connected Devices by 2020

- MOBILE DEVICES: 1.2 PER PERSON
- IoT DEVICES: 6.6 PER PERSON
- IoT DEVICES: 27.9 PER PERSON

Insufficient wireless spectrum to take the load  
Lack of network investment leading to more congestion  
TVWS compelling but ...

Data expected to explode to 70 Zettabytes (ZB) by 2020

#### Explosion of Sensors & Data

Projected Growth of Data (Zettabytes)

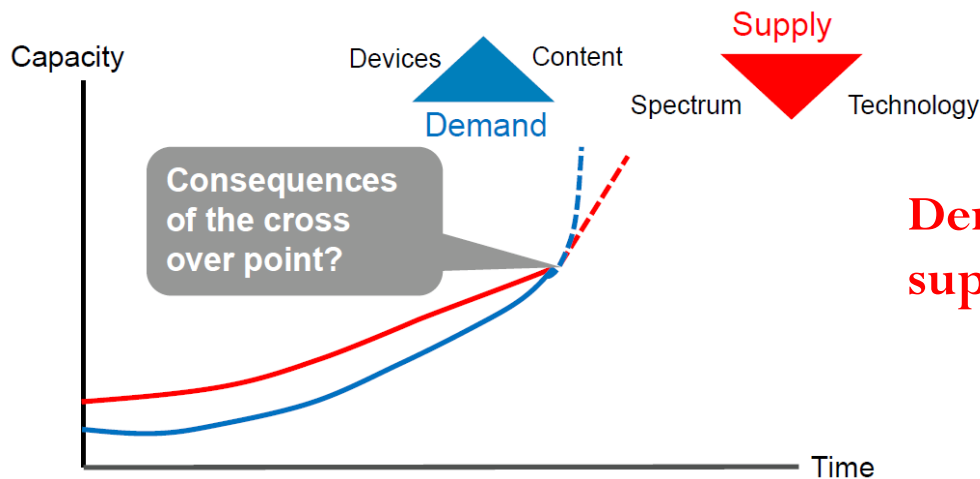
IoT Devices to grow to 50B by 2020

212 BILLION Total number of available sensor enabled objects by 2020

30 BILLION Sensor enabled objects connected to networks by 2020

212B is 28x the total population of the world

The key to enable IoT is connectivity



**Demand for spectrum will outpace supply in the next few years!!!**

# TVWS is the Answer for Scarce Spectrum

## Dr Ibrahim unveils regulations for TV White Spaces in S'pore



Above: Minister for Communications and Information Dr Yaacob Ibrahim

Singapore is the 2<sup>nd</sup> country in the world, after USA, to approve regulation for TVWS

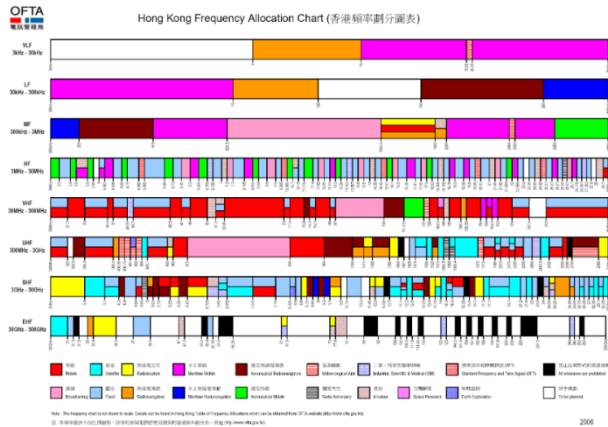
Announcing the new Masterplan 2025, Minister for Communications and Information Yaacob Ibrahim said the idea will help the nation cope with **scarce wireless spectrum** amidst rising demand for mobile Internet access.

**Except from IMM2025:** Some companies have already made some inroads. For example, the **Institute for Infocomm Research** recently designed a prototype for spectrum detection. This was later developed and commercialised with local firm Power Automation.

Through the introduction of the **TV White Space regulatory framework**, an estimated 189 MHz of spectrum will be made available for TV White Space operation.

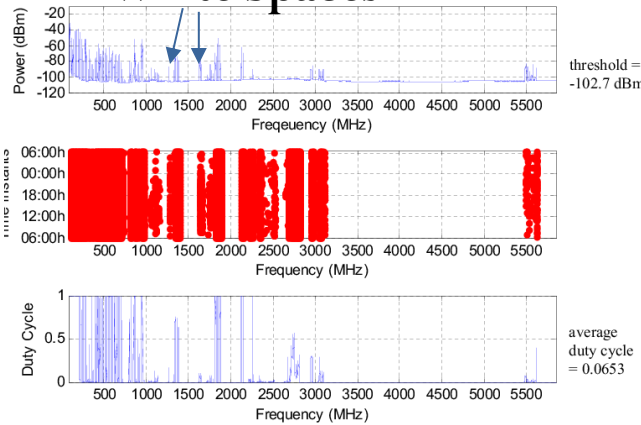
Dr Ibrahim said it is expected to result in greater capacity and data connectivity for wireless broadband internet access.

# Current way of using spectrum is inefficient → Opportunities



**Spectrum allocation ~100%**

## White Spaces



**Spectrum utilization ~6.5%**



Analog to digital TV migration  
frees up large chunk of spectrum



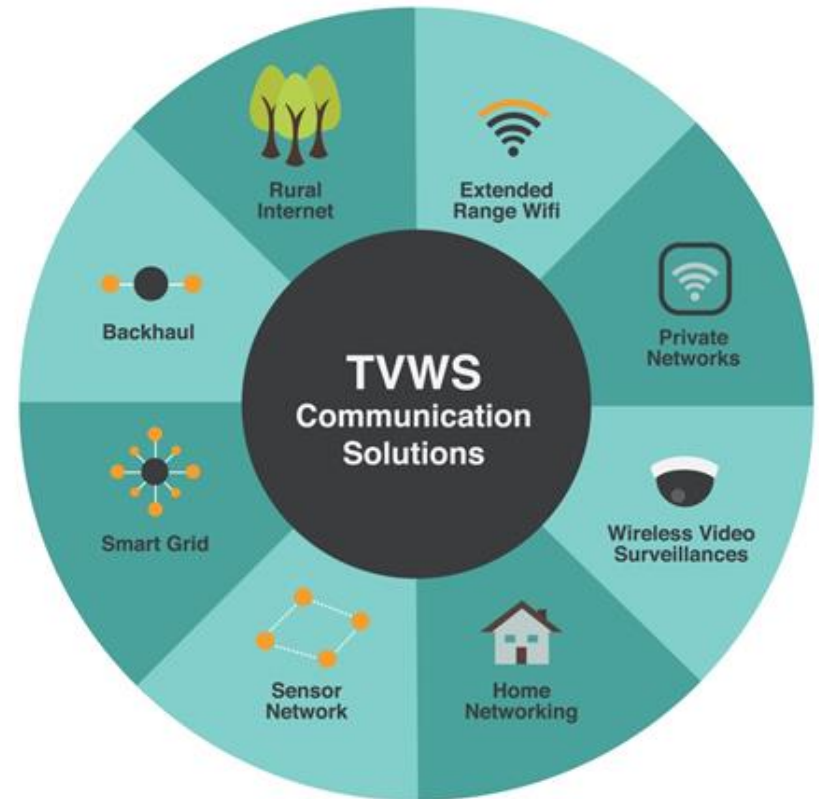
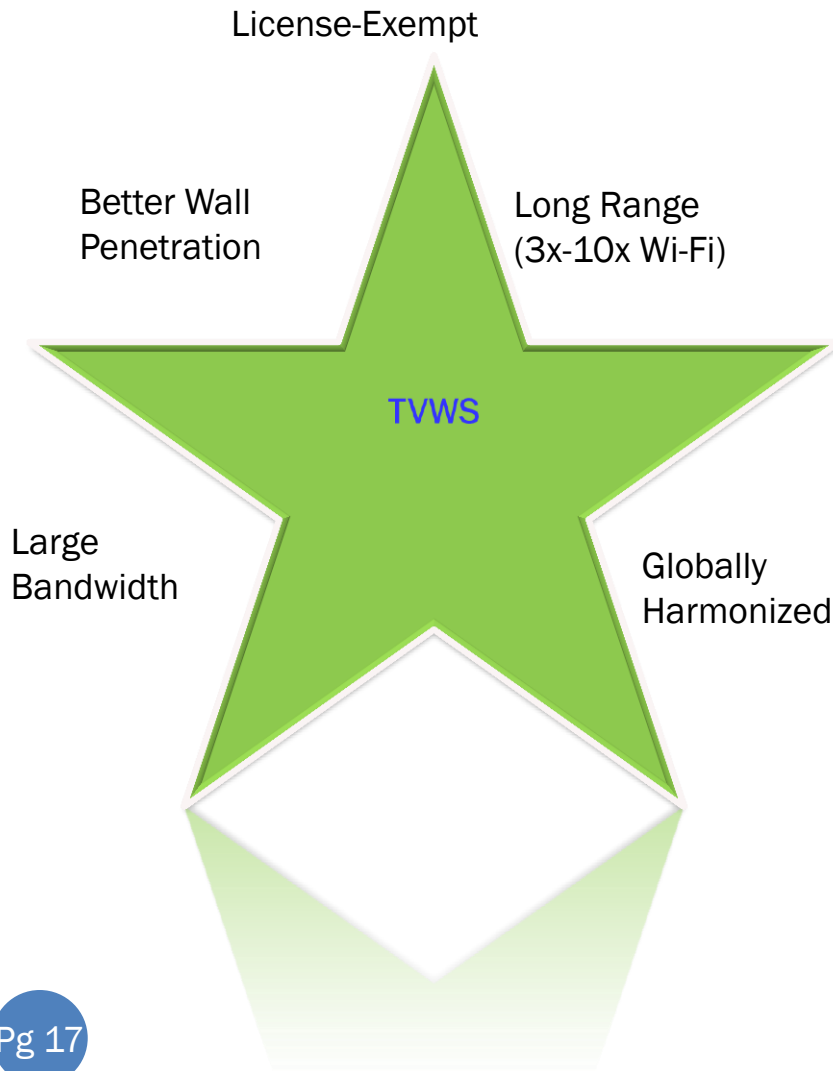
**New way of accessing spectrum** in a shared manner

→ **Sharing economy**

→ **Radical shift in communication industry**

# Key Benefits & Applications of TVWS

TVWS : One Platform, Multiple Applications



# A Global Momentum: Worldwide Regulations



★ Regulations in place

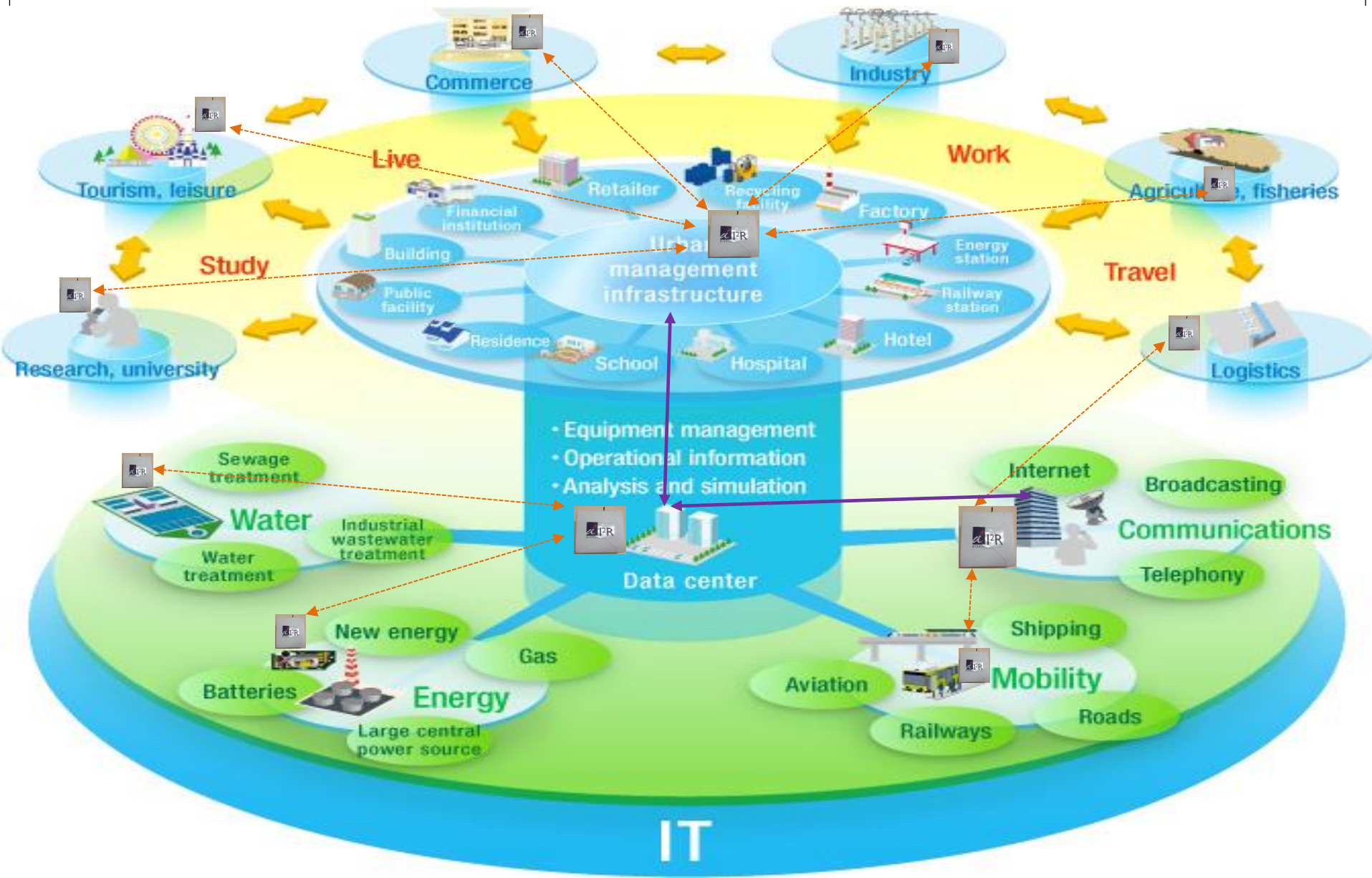
★ Govt supported trials  
(To help regulations)



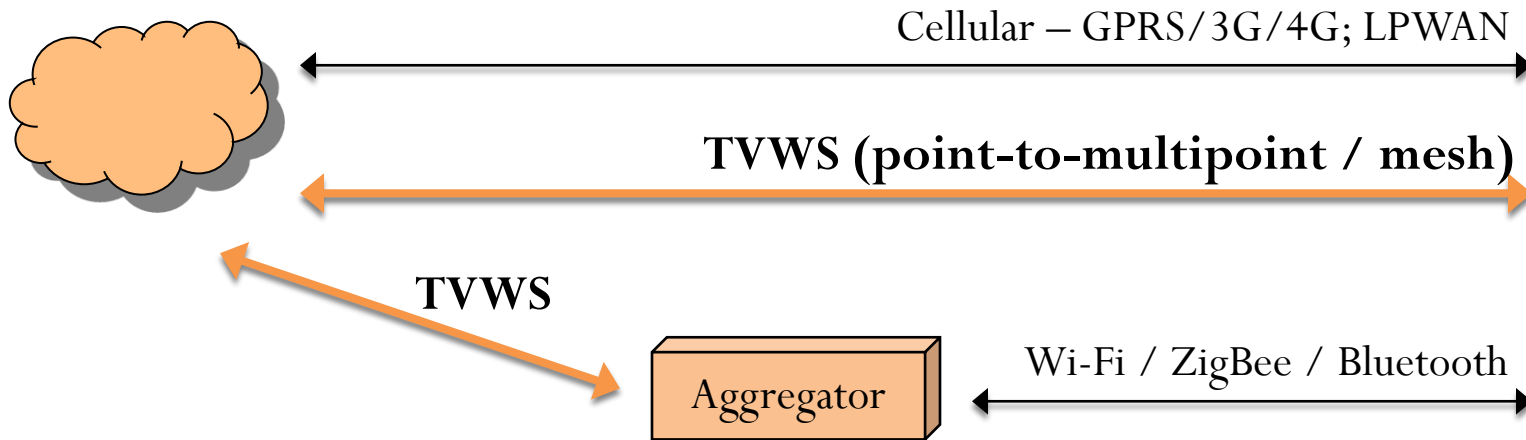
# A Global Momentum: Worldwide demo & trials



# TVWS as enabler for Smart Cities



# TVWS filling the gap for IoT!



## Devices

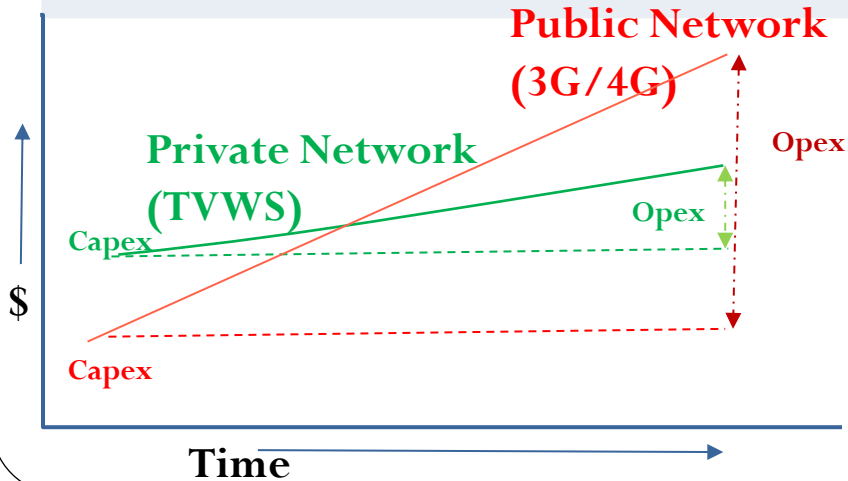


## Comparisons

Parameter	TVWS	Cellular	Wi-Fi	ZigBee
Cost	Low	Recurrent	Low	Low
Coverage	Large	Large	Small	Small
Latency	Low	High	Low	Medium
Power consumption	Medium	High	High	Low

# 3G HSPA vs. TVWS

Factors	3G HSPA	TVWS
Price (US\$/month)	40	0
Max. speed <sup>#</sup> (Mbps)	4.8 (DL), 1.3 (UL) <sup>##</sup>	13.5
Max speed at cell edge (Mbps)	0.6	1.5
Worst number of simultaneous QVGA 15 fps video streams uploads (assume 250 kbps)	2	6
Number of simultaneous 5 MHz frequency channels (assume 10)	1	10 <sup>###</sup>
Potential worst-case max number of simultaneous QVGA 15 fps per network <sup>####</sup>	2	60



Notes:

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

##Uplink (UL) speed is estimated based on downlink speed

###IDA's current TVWS framework has 24 channels available

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

# Energy & Sustainability

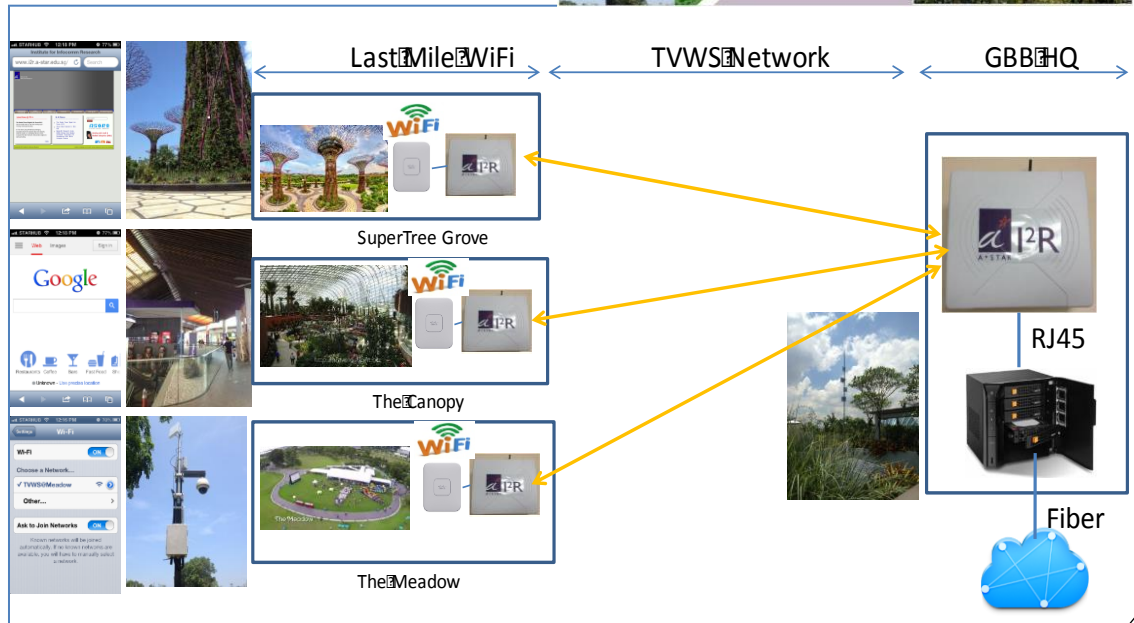


TVWS as last mile comm. for smart metering

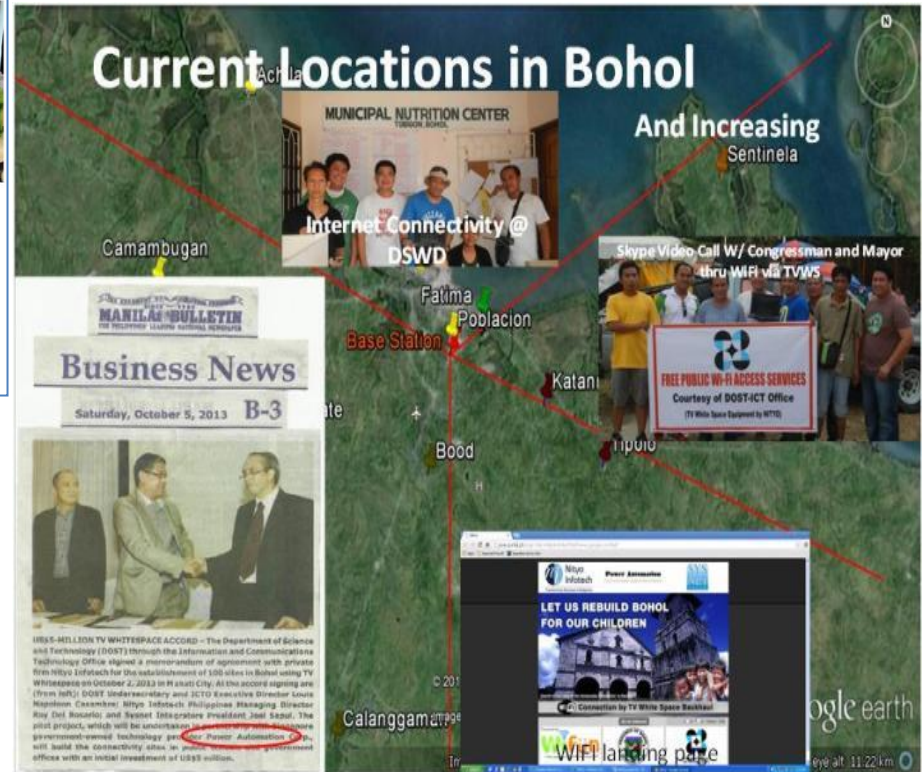
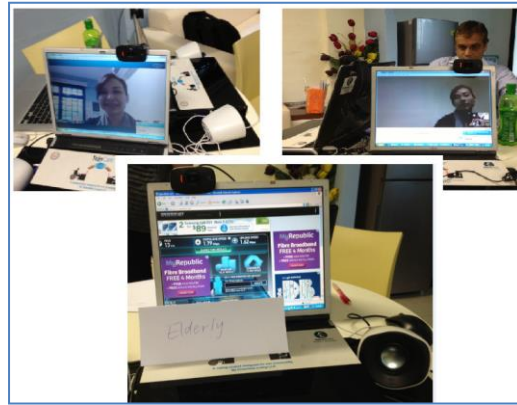
# Retail & Advertising



TVWS as backhaul to enable public Wi-Fi for visitors



# Healthcare



TVWS to enable tele-health in the Philippines



**Urban Mobility**



**Environment**



**District Management**



**Healthcare**



**Logistics**



**Manufacturing**



**Energy & Sustainability**



**Retail & Advertising**

# District Management



TVWS as comms. link for wireless surveillance



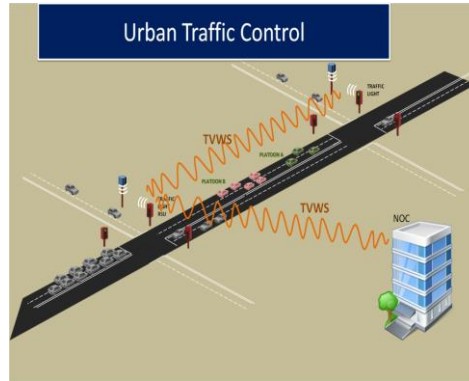
TVWS as sensor network for housing estates





# Other Smart Nation Deployments

TVWS to link up  
ITS infra

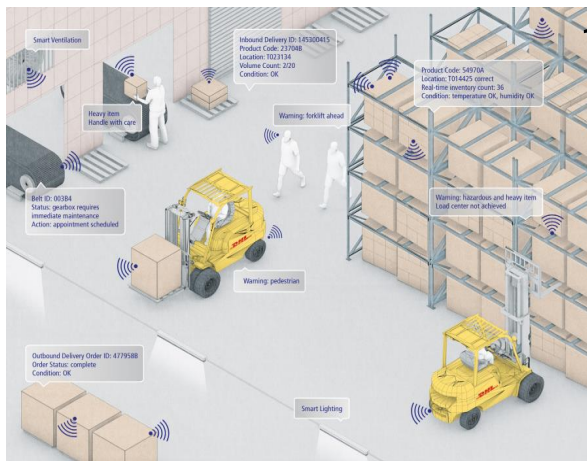


TVWS to enable smart  
bin application

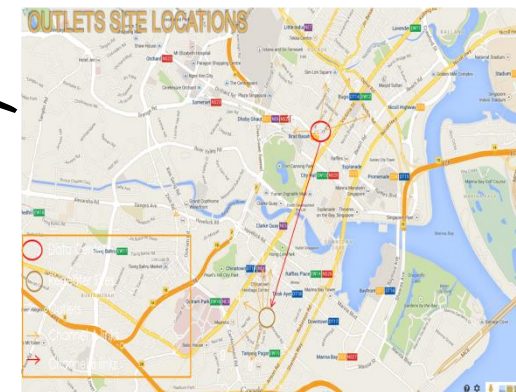
TVWS as backhaul  
for in-vehicle Wi-Fi



TVWS as comms  
for Logistics



TVWS as M2M  
machine-to-machine  
comm



# Smart cities Development in India: TVWS as Communication link



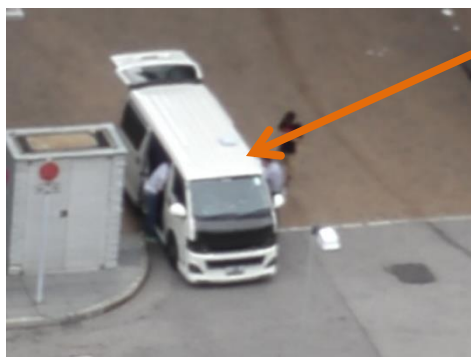
# Trial in HKSTP in August 2015



Covered Area

AP Location

TVWS



Mobile Sprinter



Live Demo to HKSTP

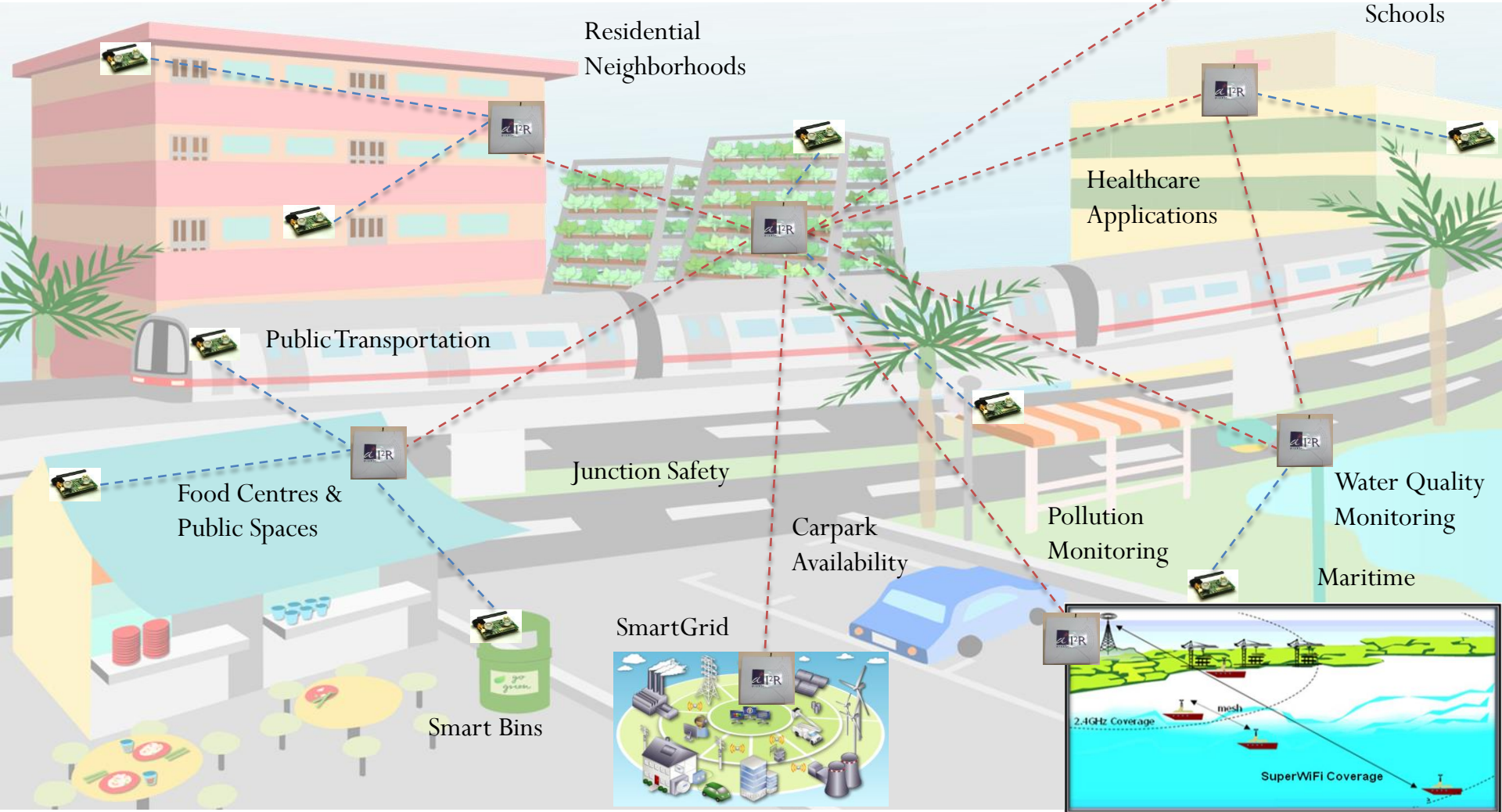


# Blueprint for Communication links in smart cities


Singapore has applied **TVWS** for Smart Nation  
 ... so can Hong Kong




Schools



 Wireless Mesh Sensor Node

 Wireless Gateway Node

 Low-power short-range wireless link, e.g. 802.15.4, ZigBee

 Powerful long-range back-haul wireless link, e.g. TV White Space

# Conclusions

Smart city requires good communication infrastructure especially wireless communications

Cellular-based communications is not fully suited for smart city applications

TVWS which has range and penetration benefits, is able to better utilize the scarce spectrum resources

TVWS has been proven in several smart city applications. You could also benefit from it!

FCC then Chairman Kevin Martin: *“Opening the white spaces... will have access to devices and services that they may have only dreamed about before.”*

# Backup Slides

# Gartner's Digital Future Prediction

2018

- 6 billion connected things will be requesting support
- 20% of business content will be authored by machines
- >3M workers globally will be supervised by a “robo-boss”
- 20% of smart buildings will have suffered from digital vandalism
- 45% of the fastest-growing companies will have fewer employees than instances of smart machines
- Customer digital assistants will recognize individuals by face and voice across channels and partners
- 2M employees will be required to wear health and fitness tracking devices as a condition of employment

2020

- Autonomous software agents outside of human control will participate in 5% of all economic transactions
- Smart agents will facilitate 40% of mobile interactions, and the post-app era will begin to dominate
- 95% of cloud security failures will be the customer's fault
- AR & VR would represent a combined market of \$150 billion