

Understanding Wireless Spectrum

Session 1.4

Wireless Spectrum



To reach people the maximum number of people affordably, wireless technologies are essential, which is why wireless spectrum has become so valuable.

Are we running out of spectrum?

The Spectrum Crunch



PHOTO: THINKSTOCK

America's wireless airwaves are full

The mobile phone industry is running out of capacity - and there's no quick or cheap fix. [More](#)

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It depends who you talk to..

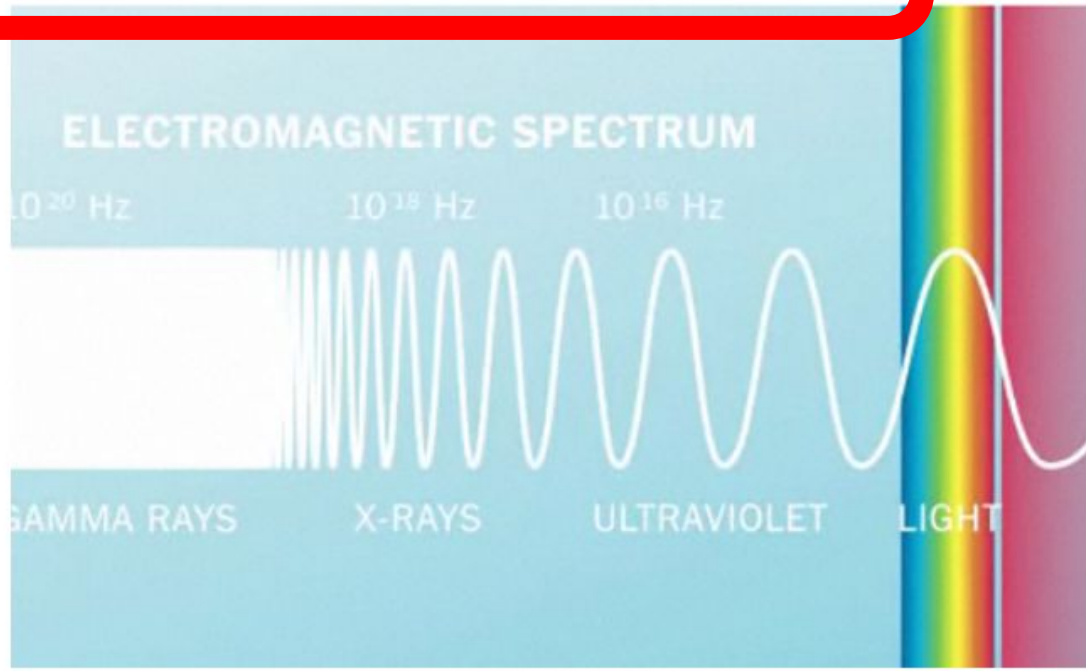
THE WIRE what matters

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The Totally Made Up Spectrum Crisis

REBECCA GREENFIELD

APR 18, 2012 4:58PM ET / TECHNOLOGY



364 VIEWS

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Wireless carriers are begging the government to give them more spectrum, claiming a coming shortage because of data-hungry cell-phone users. "The wireless carriers say that in the next few years they may not have enough of it to meet the

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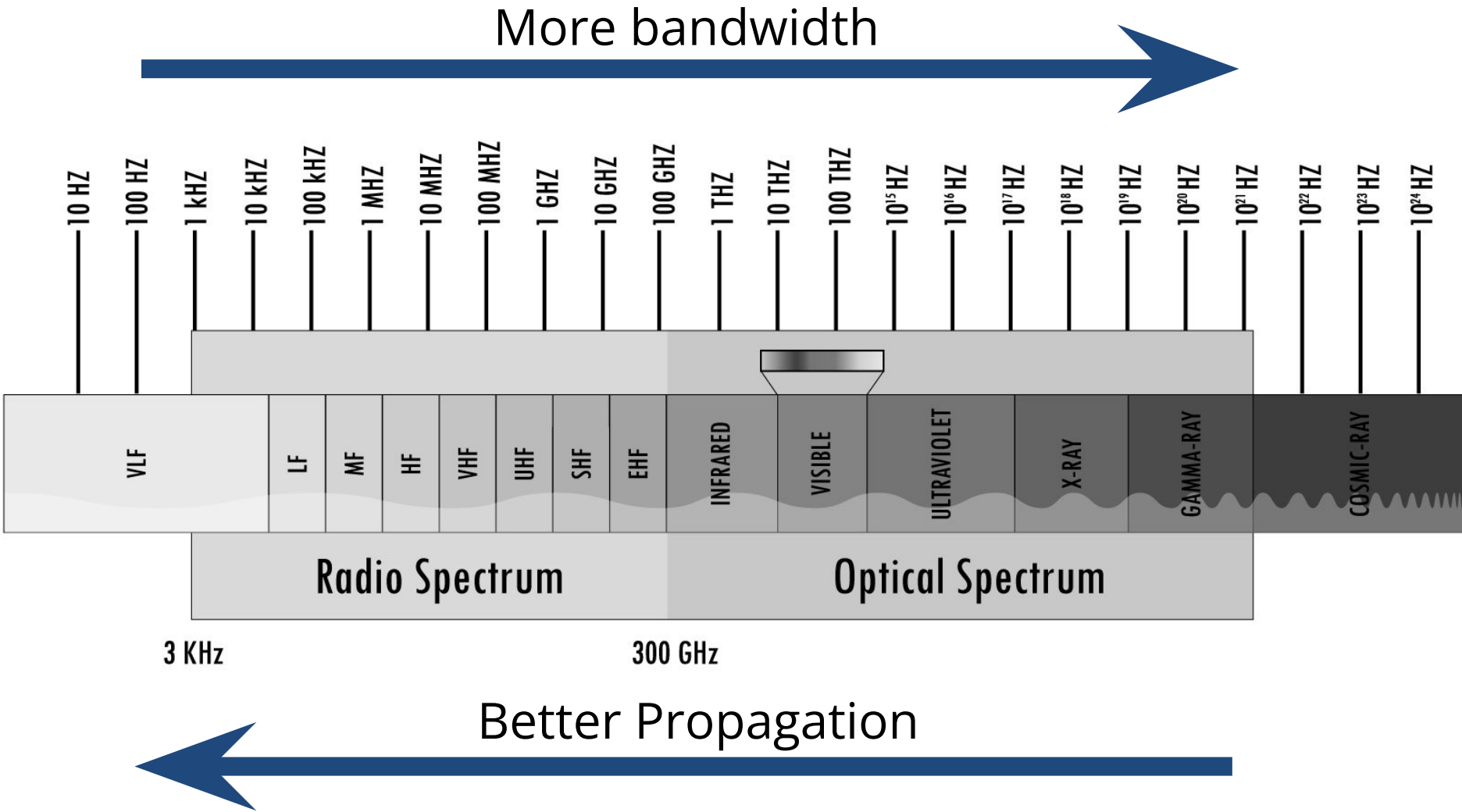


MOST POPULAR

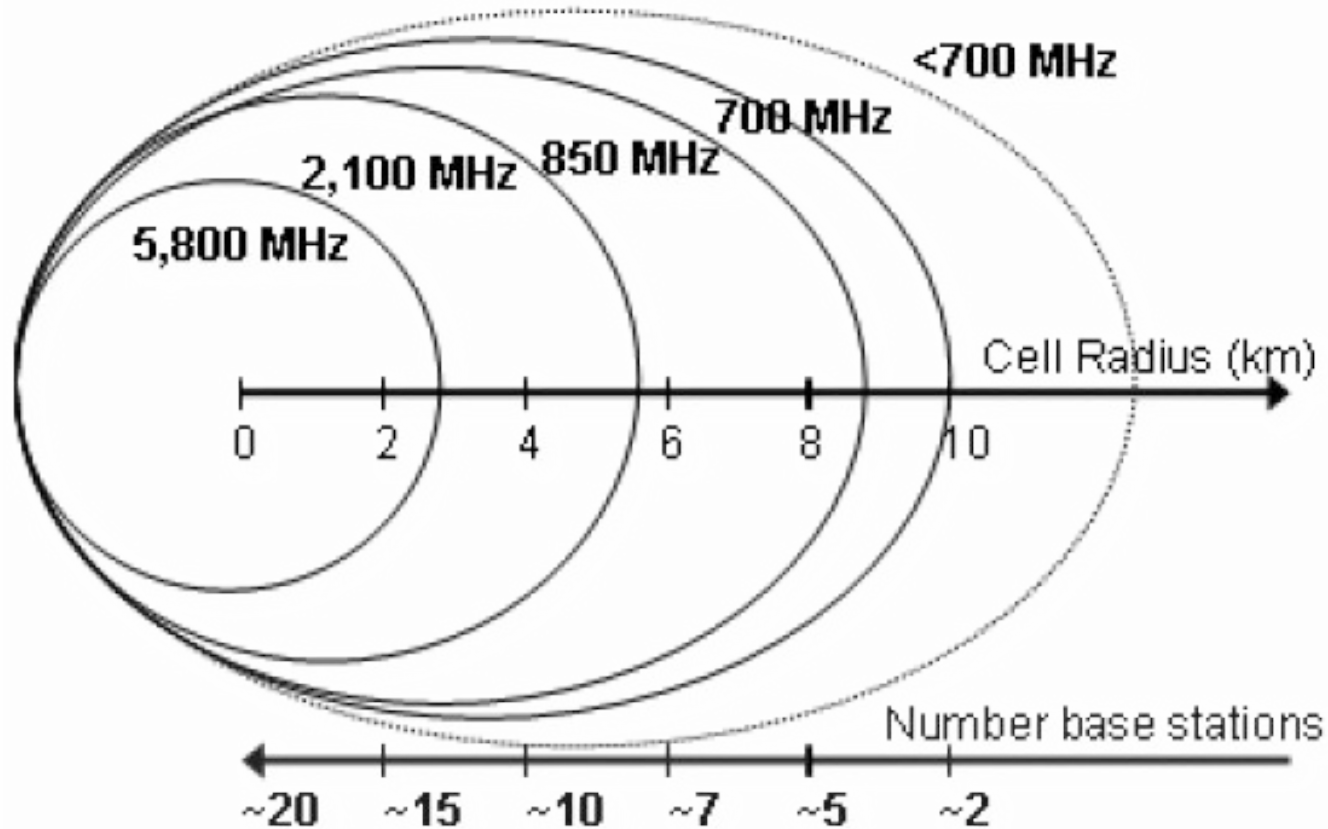
What is spectrum?



All Spectrum is Not Created Equal



Larger cell radius = lower capital cost

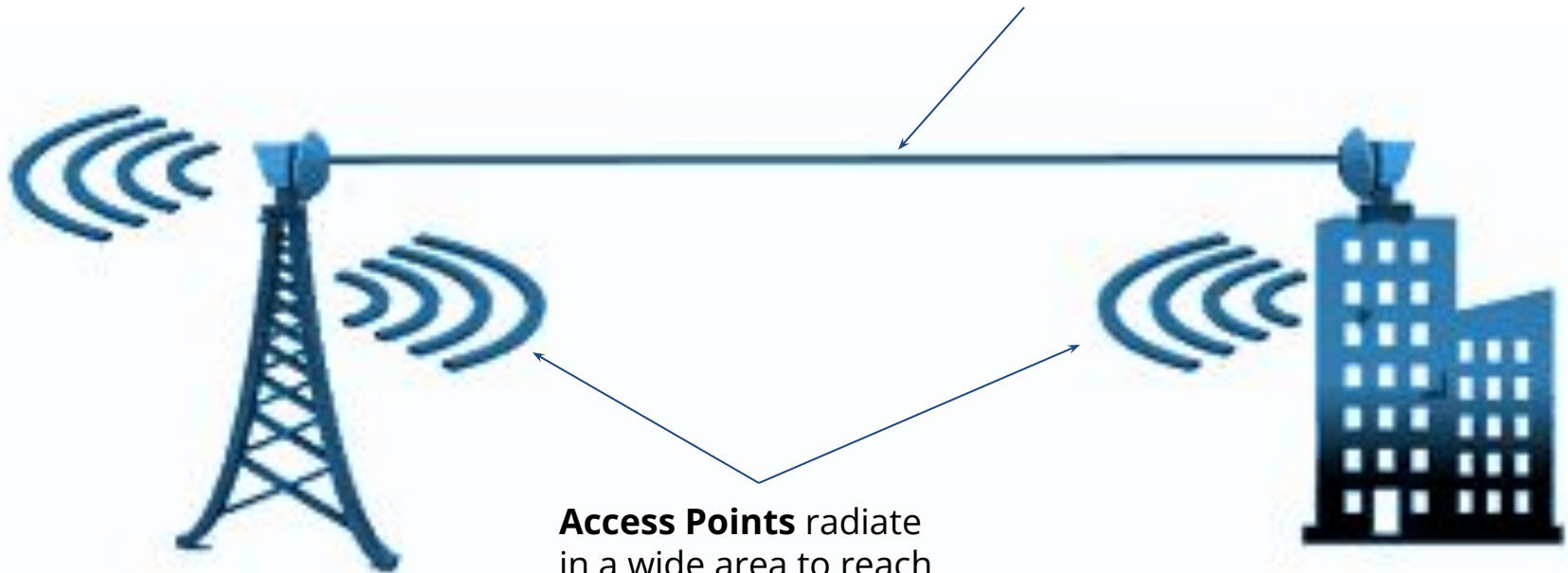


The propagation characteristics of spectrum

Source: BBC R&D.

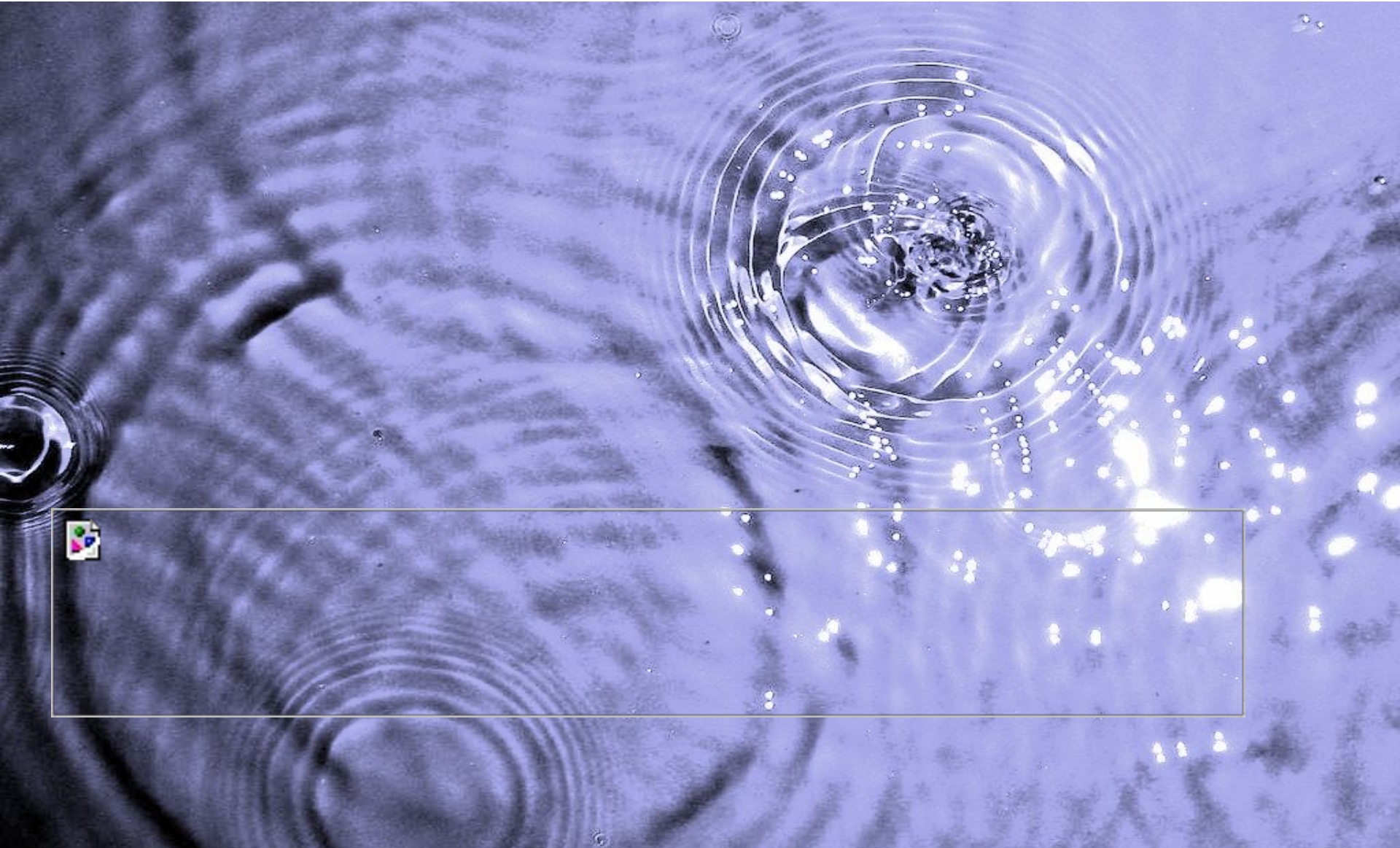
All spectrum is not used equally

Point to Point (PtP)
radio links connect
specific devices at high
speed



Access Points radiate
in a wide area to reach
client devices (phones
or WiFi APs or other
CPEs)

Why does spectrum need management?



All Spectrum is not Managed Equally

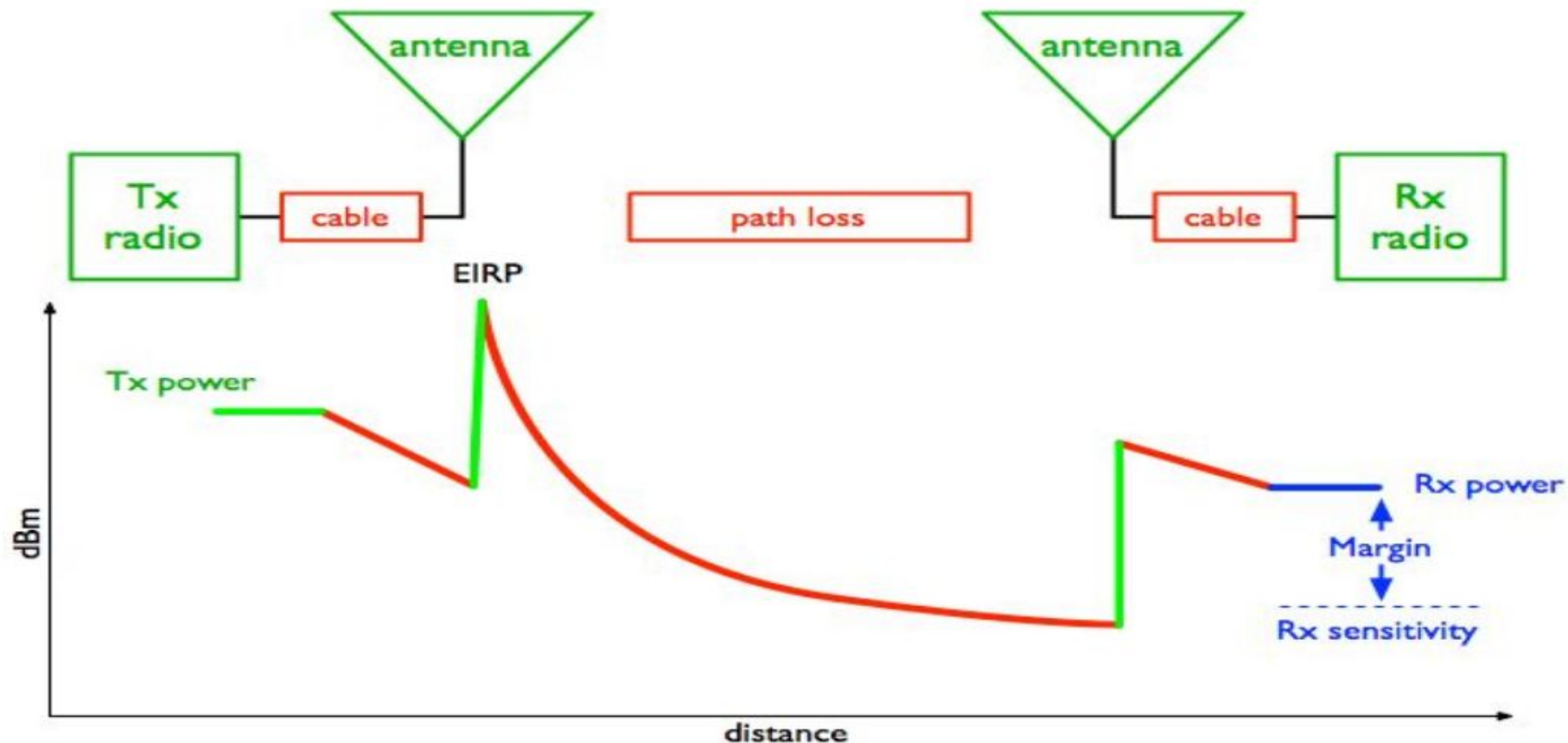


Spectrum Management

Two very different approaches

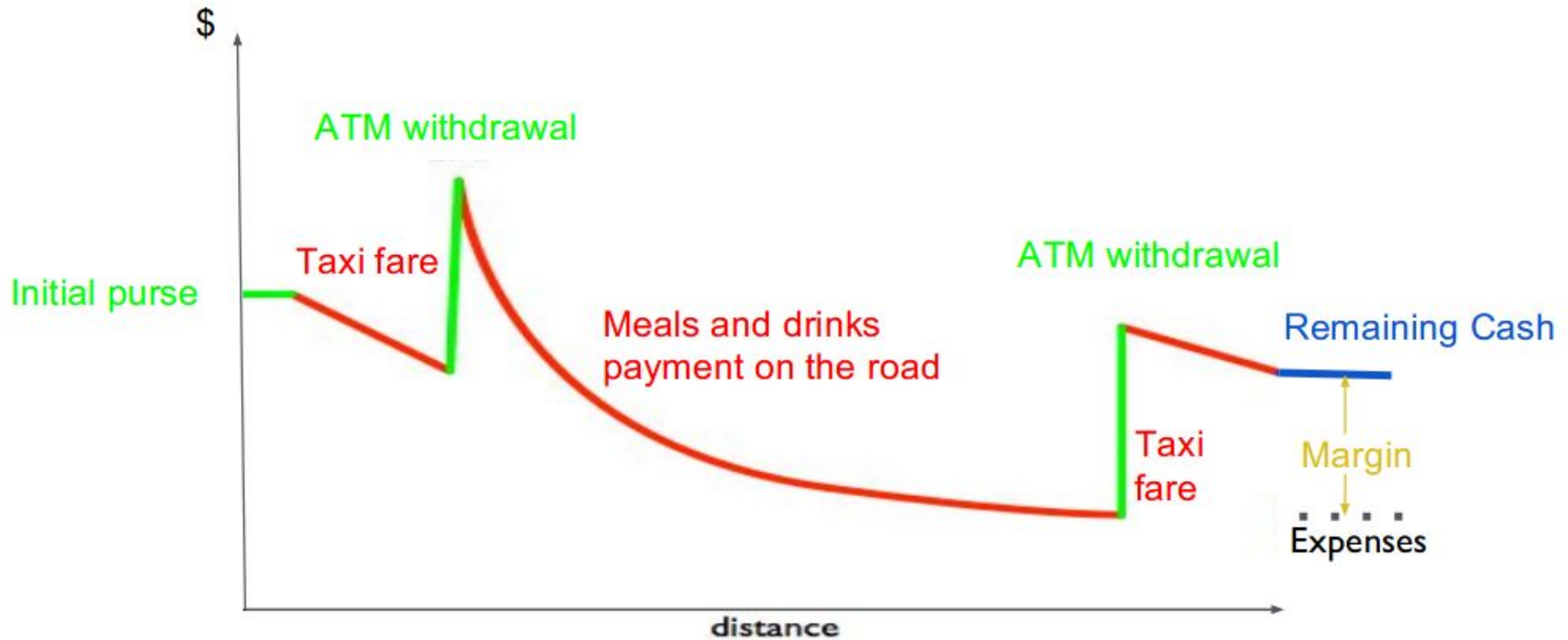
	Licensed	Unlicensed
Technology	GSM, 2G, 3G, 4G, 5G, etc	WiFi, Bluetooth, etc
Protection from Interference	License	Technology / Rules
Power Output	High	Low
Value Created	Billions \$	Billions \$
Cost of Technology	Coming down	Ridiculously cheap

Power in a Wireless System



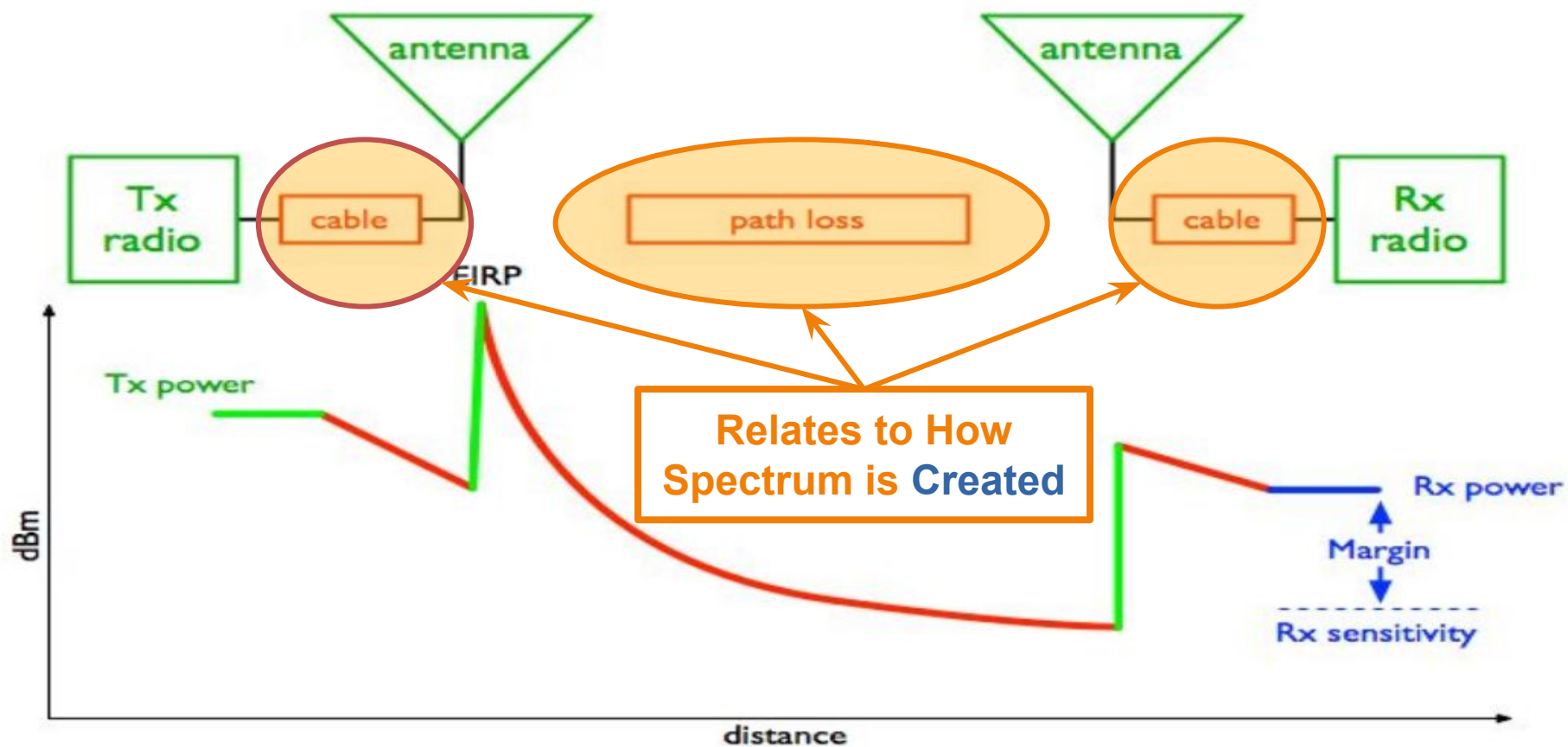
Source: <https://www.internetsociety.org/wp-content/uploads/2017/10/Link-Budget-Calculation.pdf>

Analogy of Money on Journey



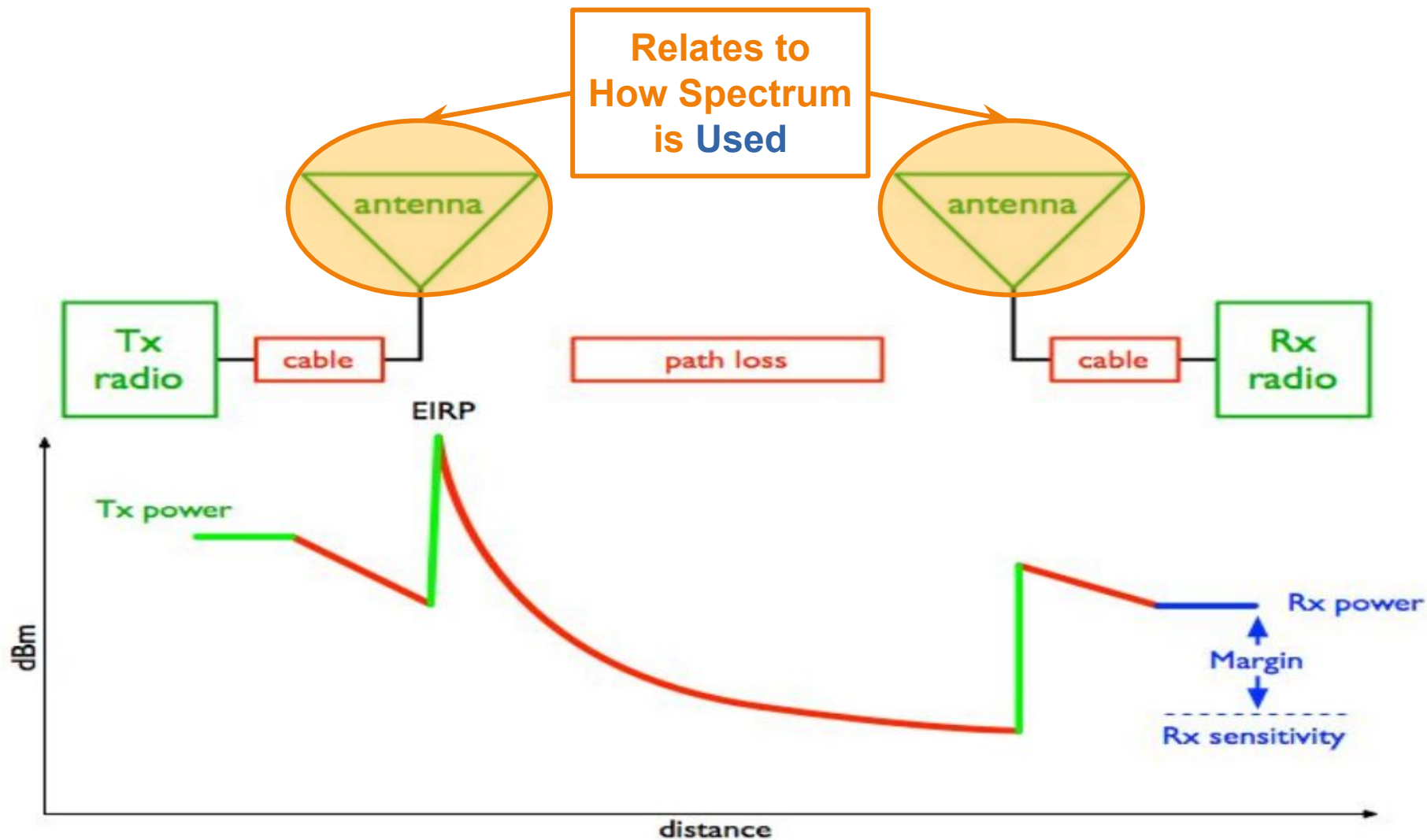
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Power in a Wireless System



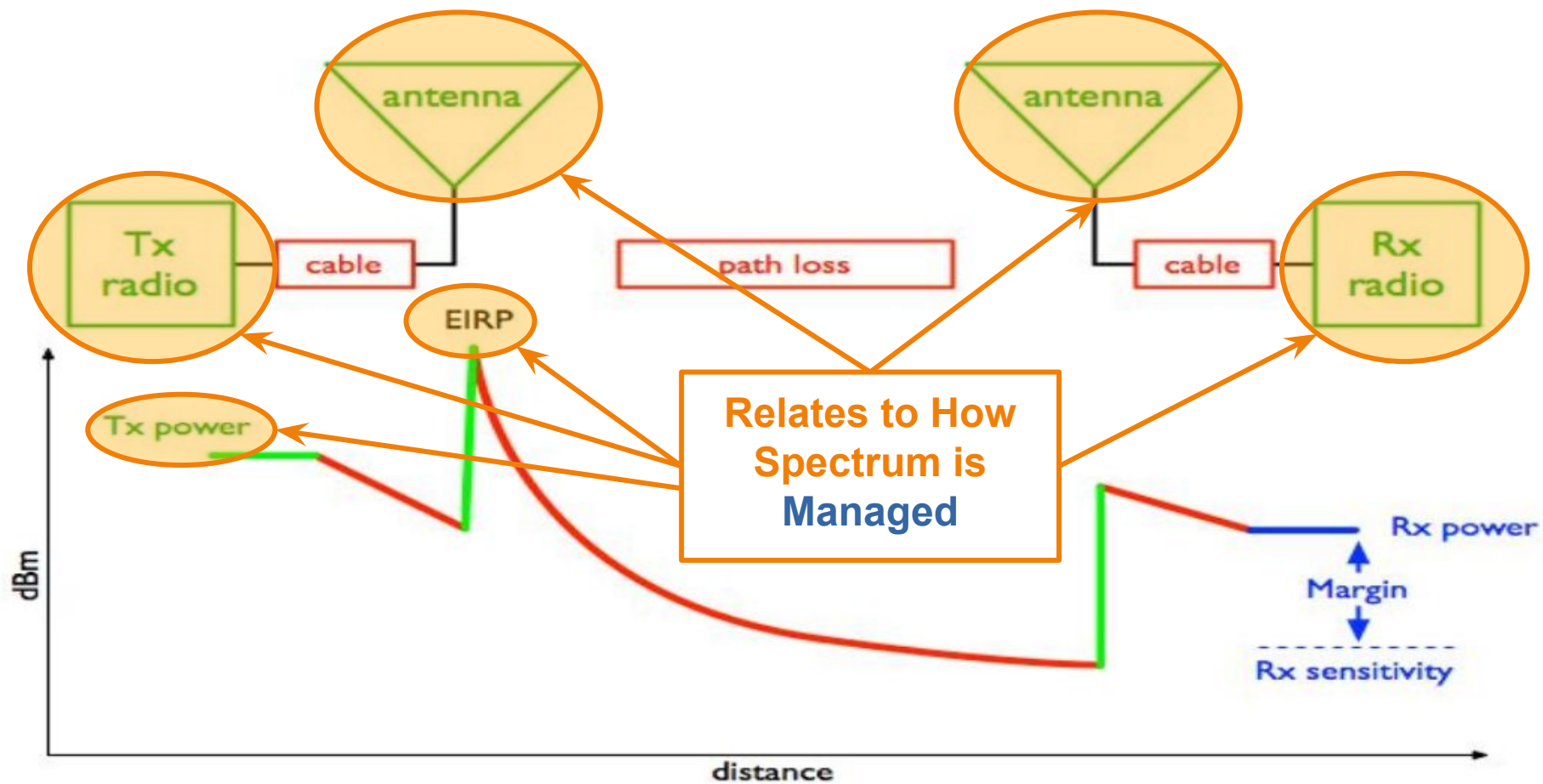
Source: <https://www.internetsociety.org/wp-content/uploads/2017/10/Link-Budget-Calculation.pdf>

Power in a Wireless System



Source: <https://www.internetsociety.org/wp-content/uploads/2017/10/Link-Budget-Calculation.pdf>

Power in a Wireless System

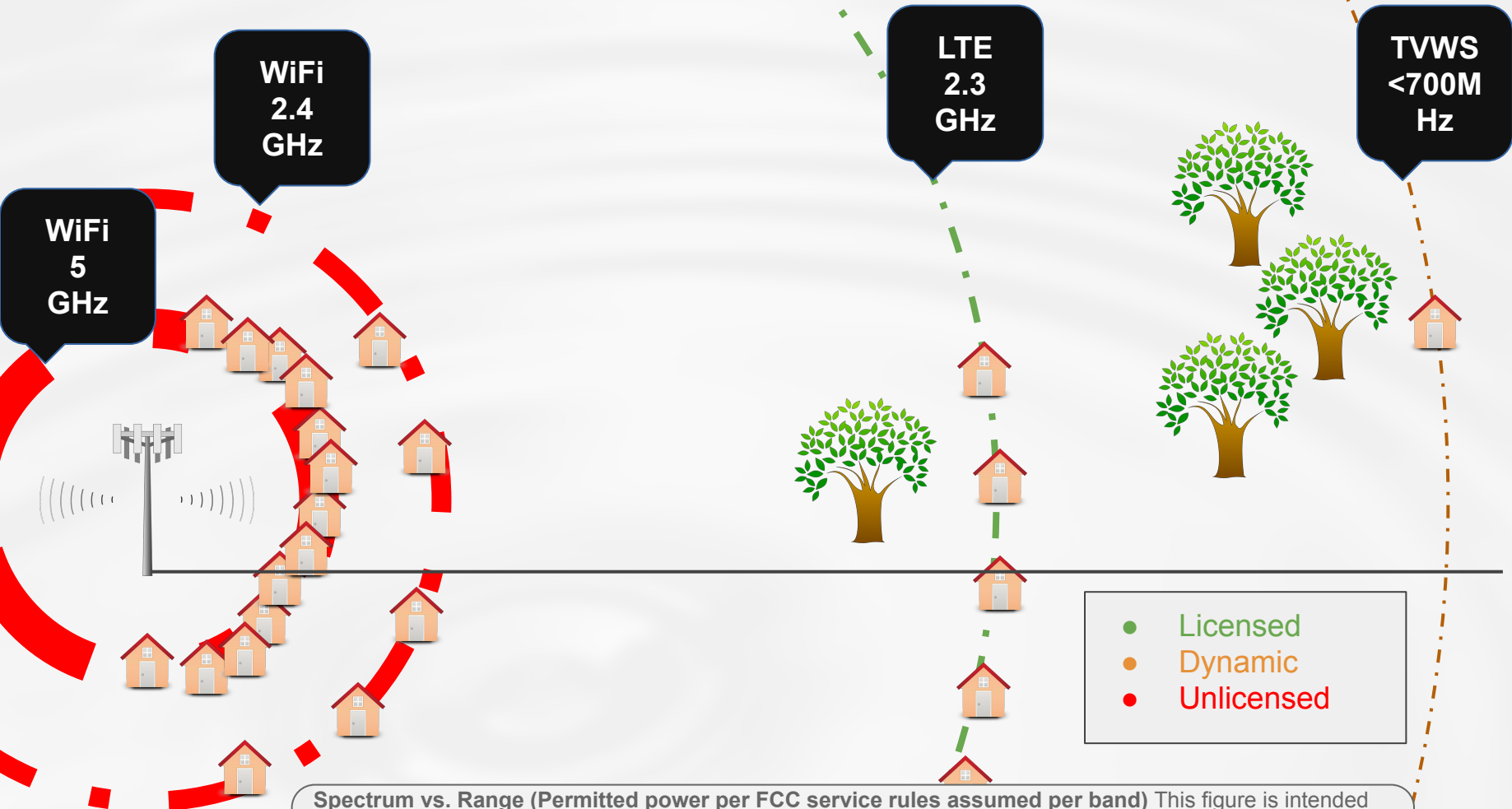


Source: <https://www.internetsociety.org/wp-content/uploads/2017/10/Link-Budget-Calculation.pdf>

Antenna examples



Frequency and Power



Spectrum vs. Range (Permitted power per FCC service rules assumed per band) This figure is intended only to suggest relative ranges and coverage areas among various single-carrier frequencies at a common received signal level (RSL) and noise floor throughout the coverage area, which may be above or below the lowest RSL at which a particular technology can operate, assuming sufficient SINR.

Based on graphic from Thompson, L. and Vande Stadt, W. "Vantage Point Solutions:5G is Not the Answer For Rural Broadband" Broadband Communities Magazine, March/April 2017

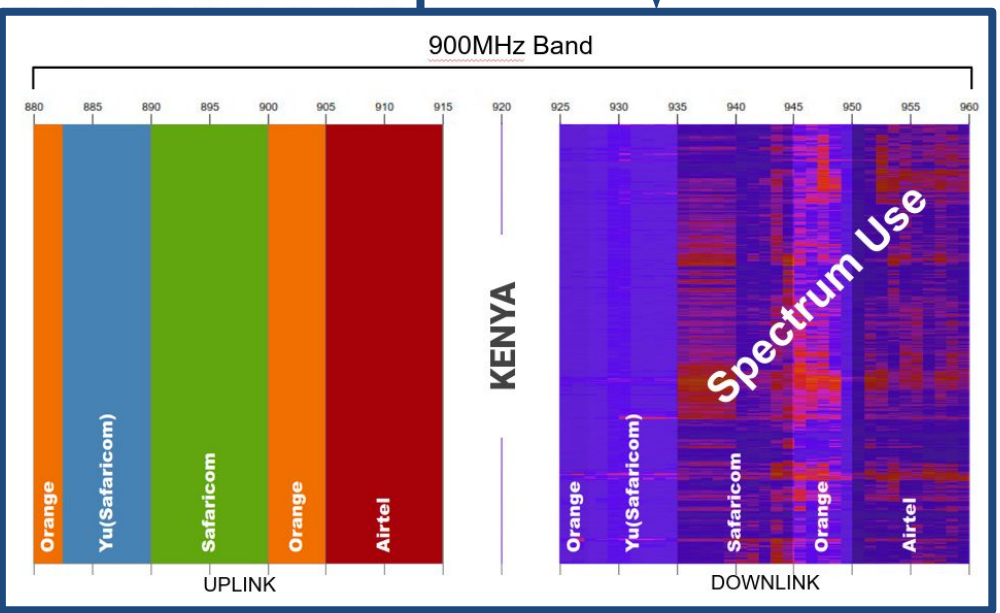
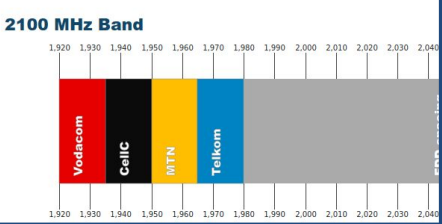
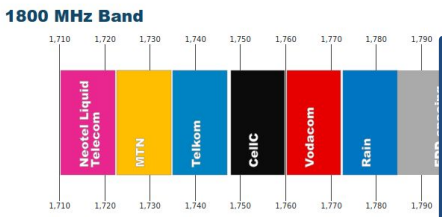
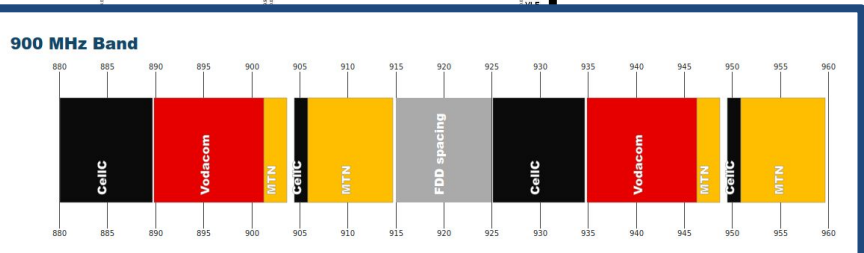
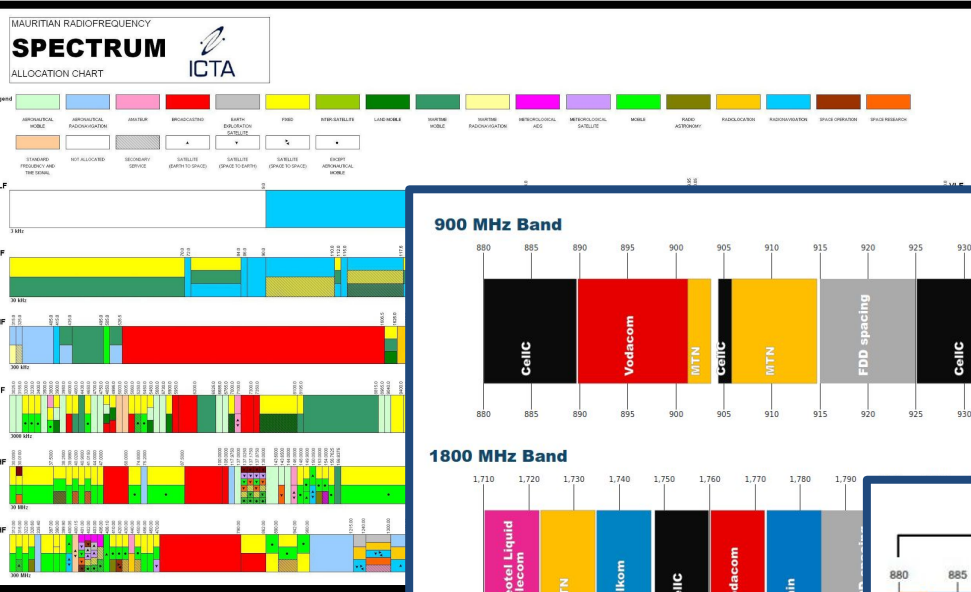
Source: The Mobile Provide: Economic Impacts of Alternative Uses of the Digital Dividend

Spectrum Allocation, Assignment, Use

Allocation
how can it be used?

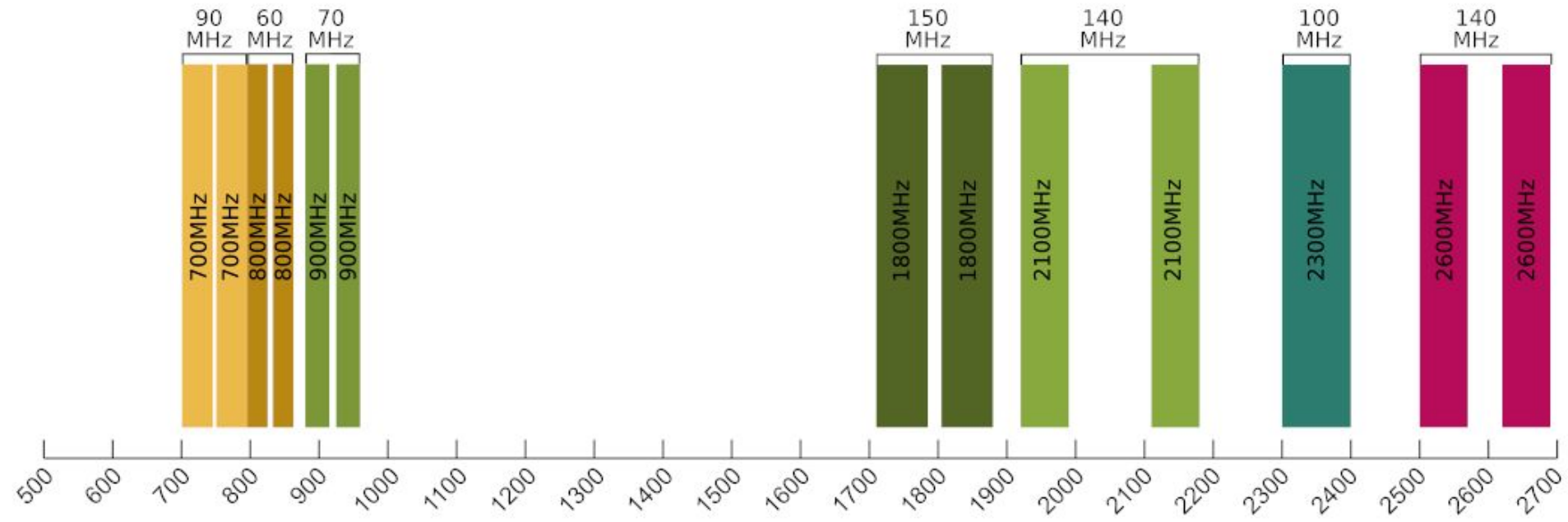
Assignment
who is licensed to use it

Use
are they using it?

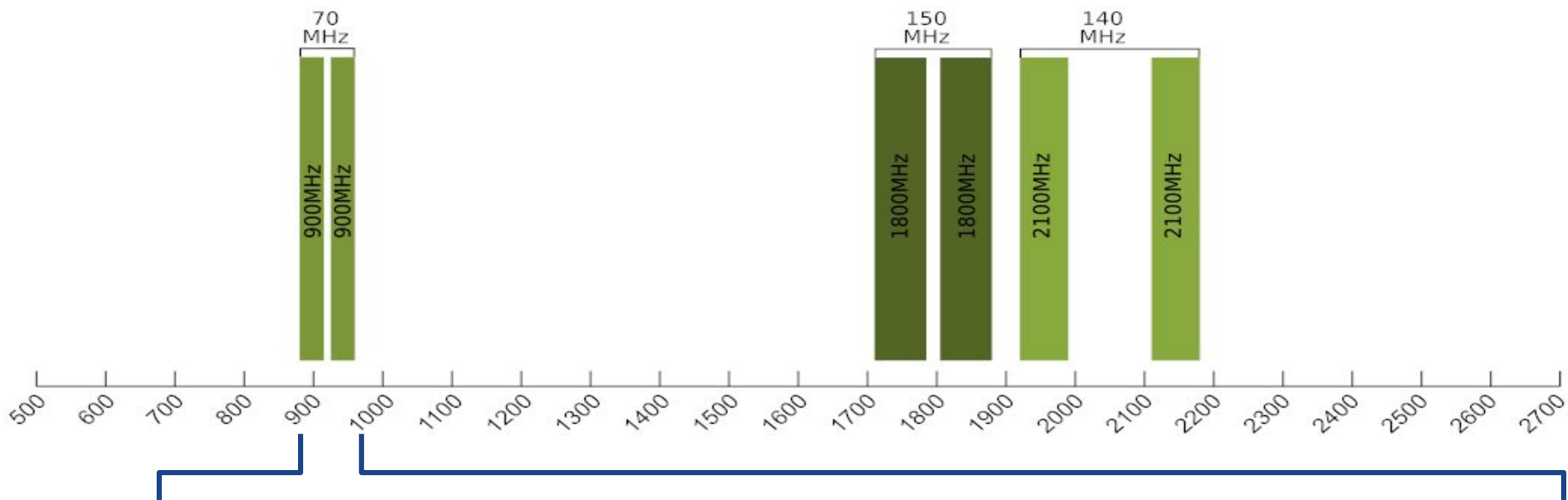


Assignment of High Demand Spectrum

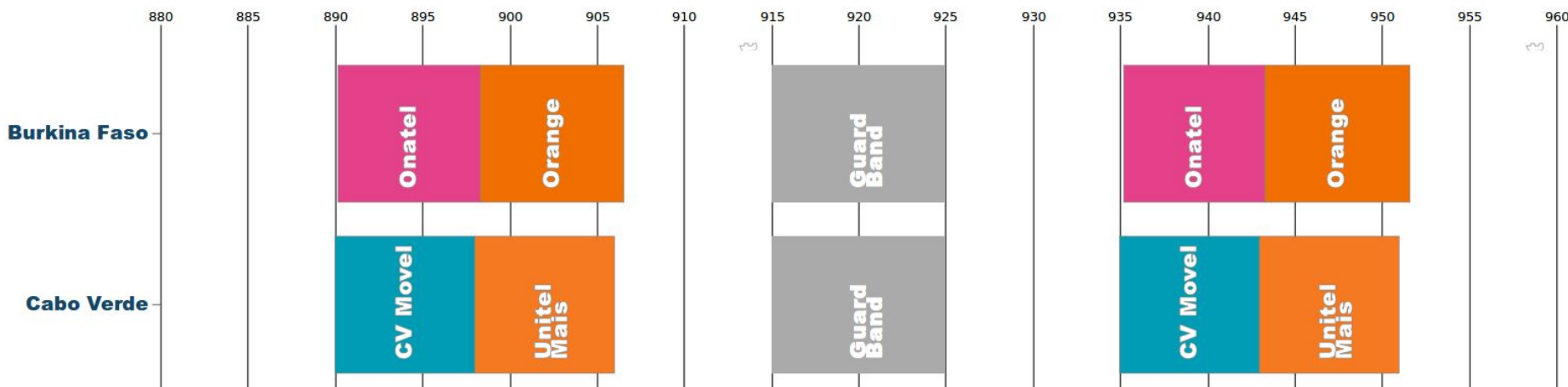
Evolution of IMT Frequency Bands



Assignments within a band



900 MHz Band



<https://opentelecomdata.org/spectrum-chart/>

High Demand Spectrum

Administrative Assignment

Pros

- Neutral - market decides
- Fair to all players
- Can be designed for social outcomes

Cons

- Can be gamed
- Raises bar for market entry
- Conflict of goals treasury / regulator

Beauty Contest

Pros

- Ensure public interest outcomes

Cons

- Prone to manipulation
- Can lead to court challenges
- Long administrative process

Auction

Pros

- Simple
- OK when supply exceeds demand

Cons

- Potentially non-transparent
- Breaks down as soon as demand increases

High Demand Spectrum

Nigeria



2013 - 2.3GHz

- 30 MHz of 2.3GHz spectrum
- 23 million USD
- won by Bitflux (a local consortium)
- 4 years later little evidence of roll-out

2014 - 2.6GHz

- 14 lots of 2x5MHz of spectrum
- Launched and withdrawn twice in 2014 then 2015
- 2016, MTN successfully bids for 6 lots meeting the reserve of \$16M per lot, a total of \$96M

Mozambique



2013 - 800MHz

- auction of five lots of 2x5MHz
- reserve price \$30M per lot
- no bids, auction withdrawn
- remains fallow for 5 yrs

2018 - 800MHz

- 800MHz, 5 lots of 2x5MHz
Reserve price \$15M million per lot
- 3 lots 800MHz auctioned at \$15M each to Mcel, Vodacom & Movitel
- 1800MHz, 6 lots of 2x5MHz
Reserve price \$30M per lot (no bids)
- 2600MHz, 9 lots of 2x5MHz
Reserve price of \$15M per lot (no bids)

High Demand Spectrum

Senegal



2015 - 800MHz (3 blocks 2x30MHz), 700MHz (4 blocks 2x20MHz) , 1800MHz (3 blocks 2x30MHz)

- reserve price set at USD50M provoking letter of complaint from operators
- negotiations ensued with the result that the former fixed-line incumbent Sonatel agree to pay **\$53M** for 2x10MHz in 800MHz band and 2x10MHz in 1800MHz band.

Ghana



2015 - 800MHz

- 2 lots of 2x10MHz (total of 40MHz)
- reserve price of 67.5M per lot (initially \$92M per lot)
- MTN sole bidder to meet reserve price
- plans for spectrum auction revenue to fund digital terrestrial broadcast infrastructure
- 2018 - Vodafone eventually secured 2x5MHz of spectrum at \$30M
- MTN may receive remaining spectrum

High Demand Spectrum

South Africa



2010 to 2022

- Three attempts since 2010 to launch auctions in 2.6GHz and 3.5GHz and more recently 800MHz
- National debate on Wholesale Open Access Network strategy, ultimately abandoned.
- Spectrum finally auctioned in March 2022 for almost one billion USD
- Plans to auction remaining spectrum.

Kenya



2014 - 800MHz

- Kenyan government agrees on exchange with largest incumbent Safaricom. 2x15MHz spectrum in exchange for \$56M plus promise to build police communications network
- Complaints filed by Airtel and Telkom
- Net result: all three operators get 2x10MHz and pay \$25M each

High Demand Spectrum

Kenya



2017 - 700MHz

- 3 blocks of 2x10MHz
- 800MHz license recipients excluded
- First block made available to Jamii Telecom (complaints)
- Consortia invited to bid for remaining two lots
- Jamii offered 10 year repayment terms
- As of 2022, no further assignment made

Tanzania



2018 - 700MHz

- Auction in Q2 2018
- \$5M reserve for 2x5MHz lots
- Two operators meet reserve, paying \$10M each for 2x10MHz
- Coverage obligations, 60% population by 2021, 90% by 2024
- One operator has since returned the spectrum

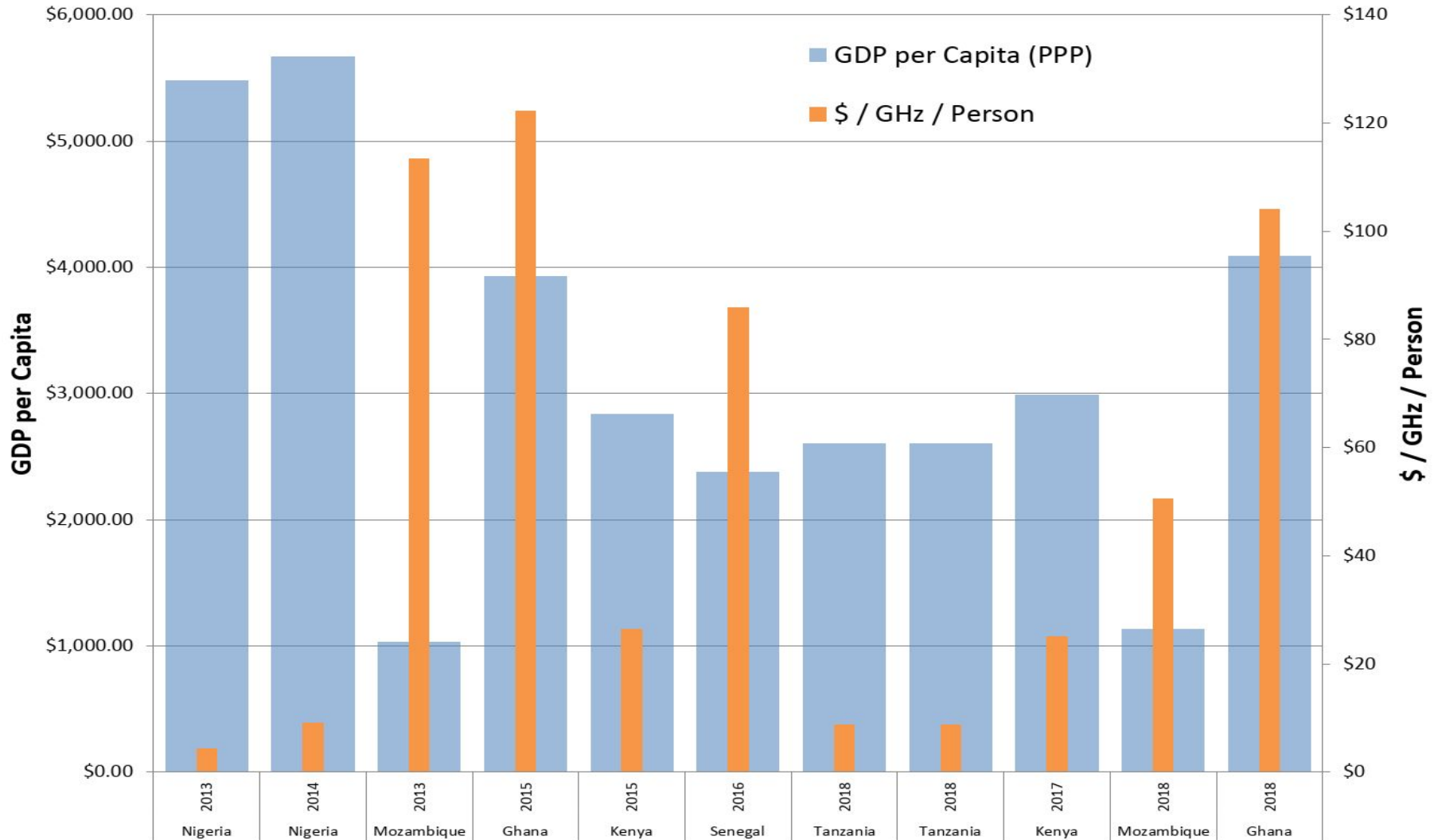
Five Years of IMT Spectrum

Country	Year	Freq	Spectrum	Price (Million USD)	# successful bidders
Nigeria	2014	2.3GHz	30MHz	23	1
Ghana	2015	800MHz	20MHz	67.5	1(2)
Nigeria	2016	2.6GHz	60MHz	96	1
Mozambique	2013	800MHz	10MHz	30	0
Tanzania	2018	800MHz	2x20MHz	20 (10 per bid)	2(1)

Source: Steve Song

Is there a right price for spectrum?

Comparison of SSA spectrum auction fees with GDP per Capita



Spectrum Auction Research

NERA research from 2017 found that high spectrum spends result in:

- Lower quality networks and reduced take-up of mobile data services owing to reduced incentives for investment;
- Higher consumer prices for mobile broadband data; and,
- Lost consumer welfare with a purchasing power of US\$250bn across a group of countries where spectrum was priced above the global median.

NERA
ECONOMIC CONSULTING



<https://www.gsma.com/spectrum/wp-content/uploads/2017/02/Effective-Spectrum-Pricing-Full-Web.pdf>

Spectrum Auction Side-Effects

- An unfortunate consequence of high value spectrum auctions is that they effectively lock small operators out of the IMT market
- Rules to ensure rural deployment of spectrum by IMT spectrum holders have not always been successful

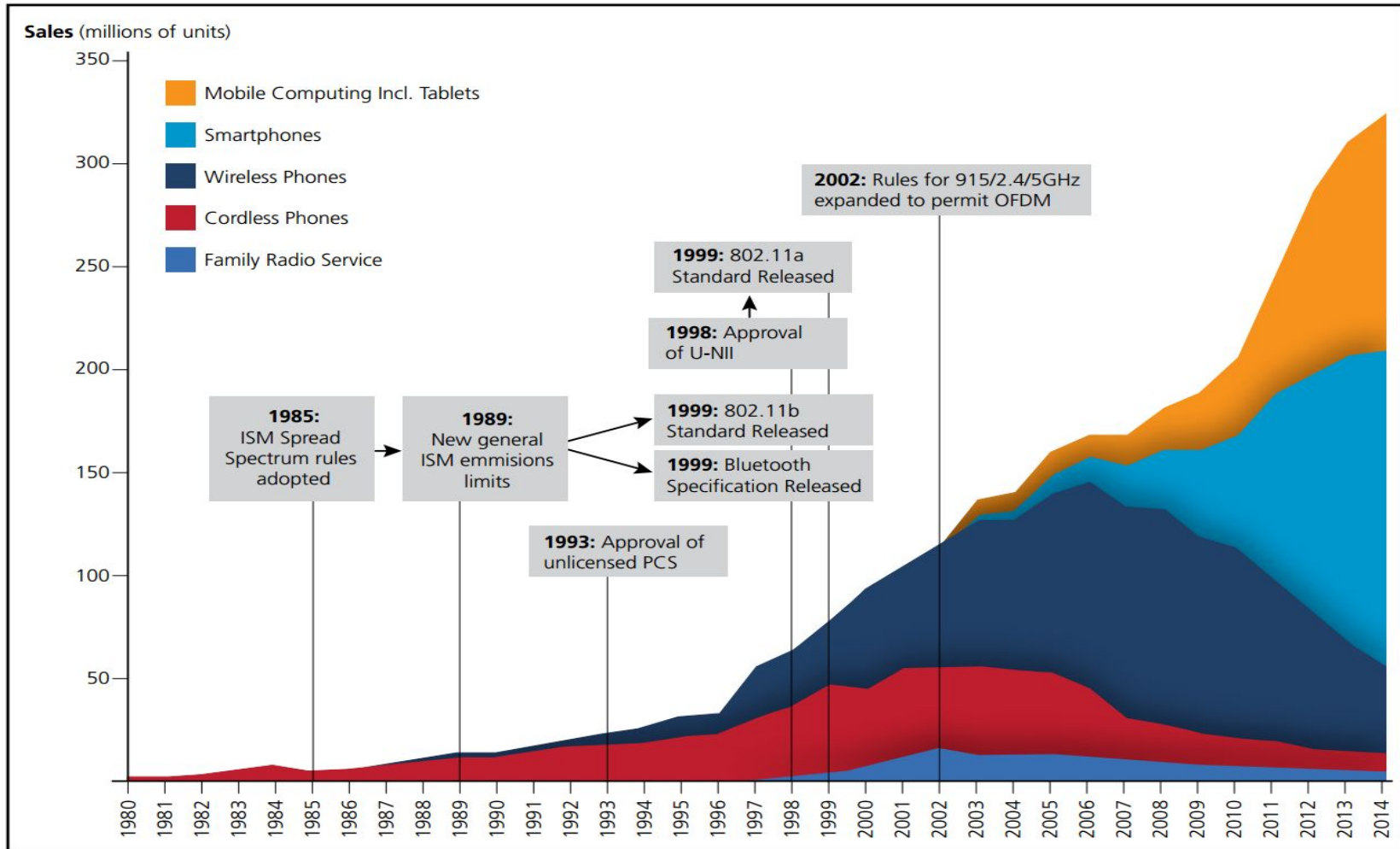


License Exempt Spectrum

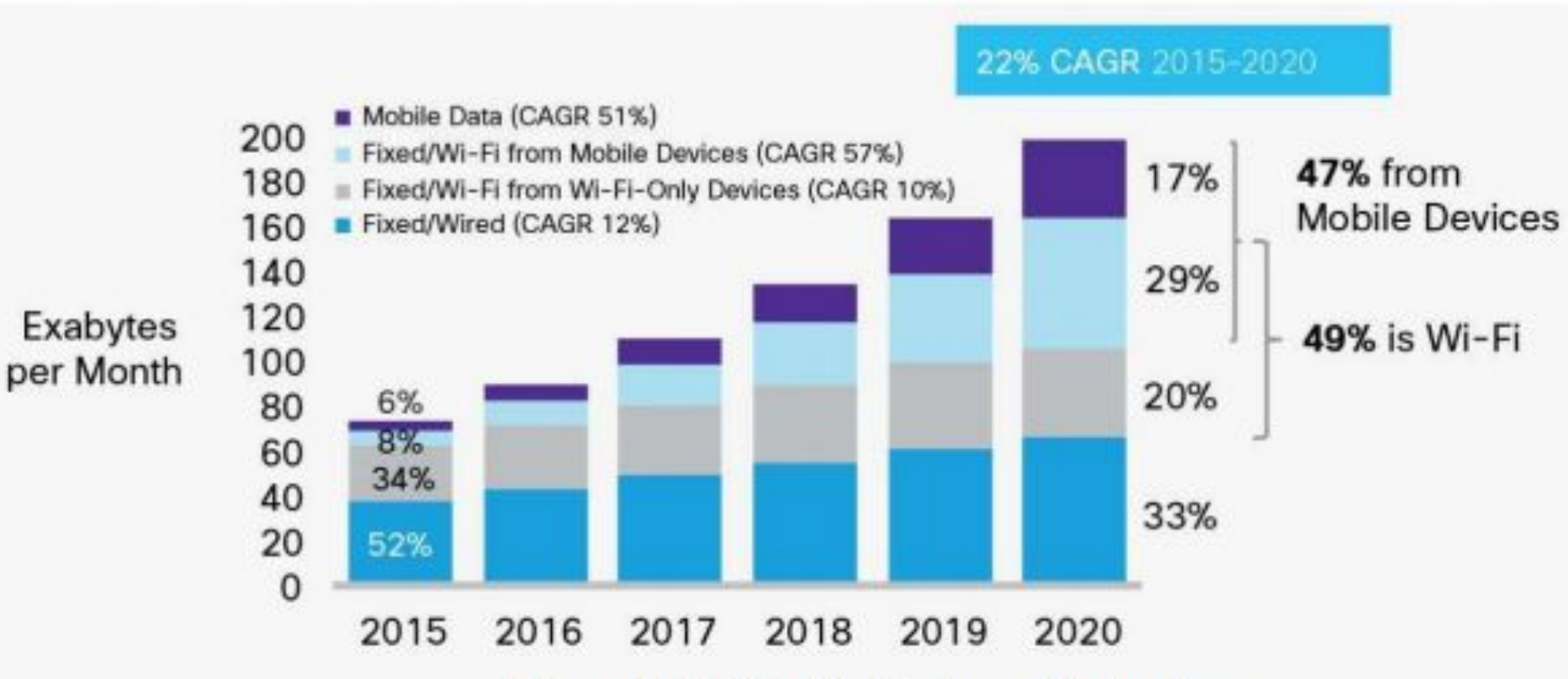
WiFi

Unlicensed Spectrum Growth

Figure 1: Unlicensed Spectrum Milestones and Selected Device Categories – Growth Over Time



Unlicensed Spectrum Growth



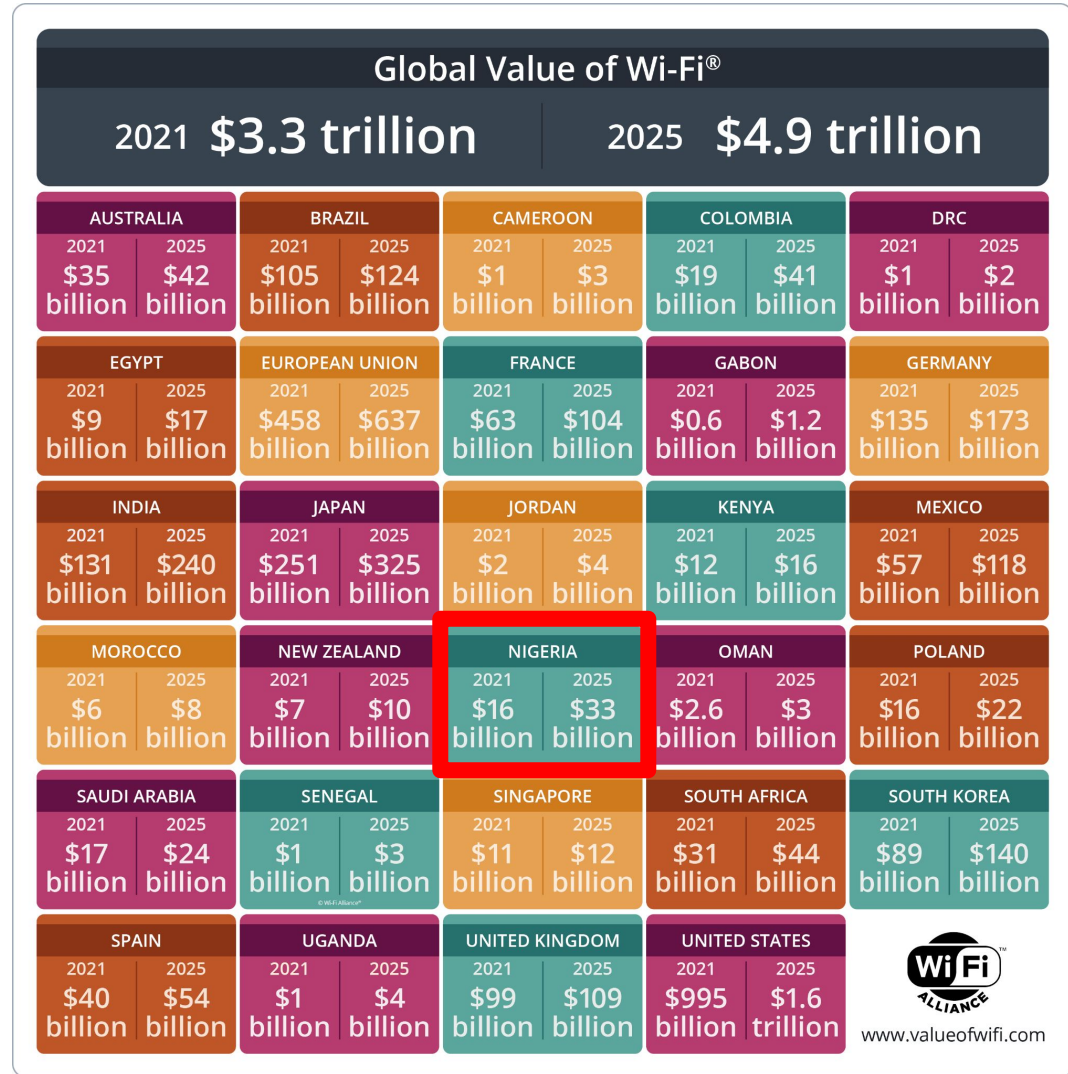
Source: CISCO Visual Networking Index - <https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.html>

The Economic Value of WiFi

The license-exempt nature of WiFi combined with its extreme affordability has enabled its meteoric growth as both an access and a backhaul technology

HOWEVER, because WiFi is limited in power output, it is also limited in application compared to licensed spectrum for mobile (IMT) use

But access to licensed spectrum is limited and often expensive



Source: <https://www.wi-fi.org/news-events/newsroom/economic-value-of-wi-fi-forecast-in-africa-middle-east-and-india>

Internet provider proposes to make Seychelles a Free Wi-Fi Nation

December 3, 2015 Africa 0 295



ROKESpot

Rokespots are a new innovative Wi-Fi service that greatly amplifies the quality, accessibility and affordability of the internet for users all around Kampala. The Wi-Fi service is made possible by a stretch of wireless signal points called Rokespots. With these Rokespots, one is able to enjoy a superior Wi-Fi connection that offers a remarkable internet experience within Kampala at the most affordable prices.

With over 200 Rokespots in Kampala, you are now able to access our Rokespot WiFi service in malls, hostels, restaurants and public places. The service has different price categories which open it up to everyone, no matter their budget.

- US\$, 1,000 gives you access for 1 day
- US\$, 5,000 gives you access for 7 days
- US\$, 18,000 gives you access for 30 days

Here's the full list of our current Rokespots in Kampala.

PRODUCT CATEGORIES
Roke at home
Roke at work
Roke on the go
ROKE LIFESTYLE
ROKE at home
ROKE at work
ROKE on the go

TECHMORAN

Government of Kenya to rollout free internet across the counties

By Staff Writer |
Posted on Sunday, July 3rd, 2016 at 4:42pm

Facebook Twitter LinkedIn YouTube

REAL ECONOMY NEWS

Movement, at last, to extend WiFi into unconnected communities

HOT SPOTS

BY ALL AFRICA MY AFRICA

news24WIRE

South Africa: Joburg Promises Free Wi-Fi for 'All Residents'

Tagged: Business, Governance, ICT, South Africa, Southern Africa

Plans are afoot to have all 4 million citizens in Johannesburg connected to free Wi-Fi within five years.

Zolani Matabese, Head of Broadband for the City of Johannesburg, told Fin24 that 1 000 hot-spots for access to the internet would be installed around the municipality by year-end.

Mmegi online

3oFiNet rolls out 600 Wi-Fi hot spots

Business

EXCHANGE RATES

FOREIGN / PULA

IT NEWS AFRICA

Kenya: Libraries to offer free Internet to pupils

May 30, 2016 - East Africa, Education, Top Stories

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Fast affordable WiFi internet for Kenya.

Our coverage in Kibera is provided by 56 Poa! zones giving over 1,760,000 m2 coverage.

FREE PUBLIC INTERNET ACCESS (WiFi) NITA - Google Chrome

IT CERTIFICATION

FREE PUBLIC INTERNET ACCESS (WiFi)

Friday, September 30, 2016

As pledged by H.E the President in the NRM manifesto, the Ministry of Information Technology and National Guidance through its mandated agency National Informatics Authority Uganda (NITA-U) has commenced the trial provision of free wireless access in Kampala Central Business District and parts of Entebbe effective 1st October 2016.

FREE WI-FI INITIAL COVERAGE MAP

#MYUG

Internet access is no longer a luxury but a necessity for all Ugandan citizens. The IT remain at the center of this country-wide transformation steering Uganda to world class and productivity!

With H.E the President's support, Phases I and II of the National Backbone Infrastruc. were completed and Phase III of the NBI is nearing completion.

As a result, 169 Ministries, Departments and Agencies (MDAs) and Local Government now connected. 102 MDAs are being connected this FY 16/17, and more will be connected.

ECHCENTRAL

pe Town MyCiti buses to get free Wi-Fi

City of Cape Town has announced the launch of a free Wi-Fi pilot on its buses.

City of Cape Town has announced the launch of a free Wi-Fi pilot on buses.

TIZETI

Fast Wifi Technology

In Africa, despite its slow start and almost nonexistent infrastructure Tizeti is building Wi-Fi solar base stations to provide affordable unlimited internet service across Africa.

Solar Powered Base Station

Moçambique comprometido com a Inclusão Digital

Publicado em 08 Junho 2022

perspective and policy defining. One of the actions was to start using universal access fund. Since 2018 we are implanting three

Na Mesa Redonda em referência, os representantes dos vários países do mundo que participam na WTDC-22 informaram as necessidades, compromissos, estratégias e recursos disponíveis para a superação da exclusão digital. O Fórum constituiu oportunidade para o estabelecimento de parcerias para a conectividade universal significativa.

Tuaha Mote, partilhando a realidade de Moçambique sobre a inclusão digital, referiu-se ao facto de a maior parte dos perto de 30 milhões de habitantes residir em zonas rurais, aliado a uma dispersão populacional acentuada e com um poder de compra muito baixo. Em segundo lugar, afirmou-se como grandes desafios ao investimento privado em comunicações no país. Continuando, informou que o Governo Moçambicano definiu acções concretas para transformar o país de não-conectados em conectados, disponibilizando dos serviços de Internet de Banda Larga, a boa qualidade de experiência, a alocação do espectro de forma equitativa, bem como a alocação do espectro reservado no modelo leasing.

Para a materialização das acções supracitadas, o Governo de Moçambique compromete-se a implantar praças digitais com Wi-Fi de alta velocidade, em todos os 154 distritos do país, até 2024. Igualmente irá garantir, até o mesmo período, o acesso gratuito à internet em cerca de 620 escolas secundárias, afirmou Mote.

Importa referir que desde o início da implementação destes dois projectos em 2018, foram implantadas 93 Prças Digitais e a conectividade rural, foram cobertas cerca de 40 escolas.

License Exempt Spectrum

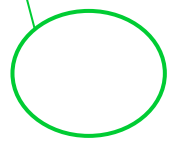
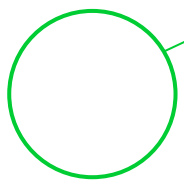
WiFi

	2400 – 2483.5 MHz		5250 MHz		5350 MHz		5600 MHz		5600-5650		5650-5725		5725 – 5850 MHz	
	EIRP	Tx Power	EIRP	Power	EIRP	Power	EIRP	Power	EIRP	Tx Power	EIRP	Tx Power	EIRP	Tx Power
South Africa	20 dBm		23 dBm		20 dBm		20 dBm				20 dBm		30 dBm (PtP)	30 dBm
United States	36 dBm in dBm PtP of 30 dBm in dBm PtP of 30 dBm	30 dBm	30 dBm	30 dBm	24 dBm	24 dBm	24 dBm	24 dBm	24 dBm	24 dBm	24 dBm	24 dBm	30 dBm	30 dBm
Canada	36 dBm in dBm PtP of 30 dBm	30 dBm	20 dBm		24 dBm	24 dBm	24 dBm	24 dBm			24 dBm	24 dBm	30 dBm	30 dBm
Nigeria	30 dBm				23 dBm		23 dBm						30 dBm (max)	

Why not WiFi here?

Why limit gain?

Why no PtP case?



Source: Innovations in Spectrum Management
https://www.internetsociety.org/wp-content/uploads/2019/03/InnovationsinSpectrumManagement_March2019-EN-1.pdf

License Exempt Spectrum

Expanding the WiFi ecosystem

Expanding license exempt spectrum



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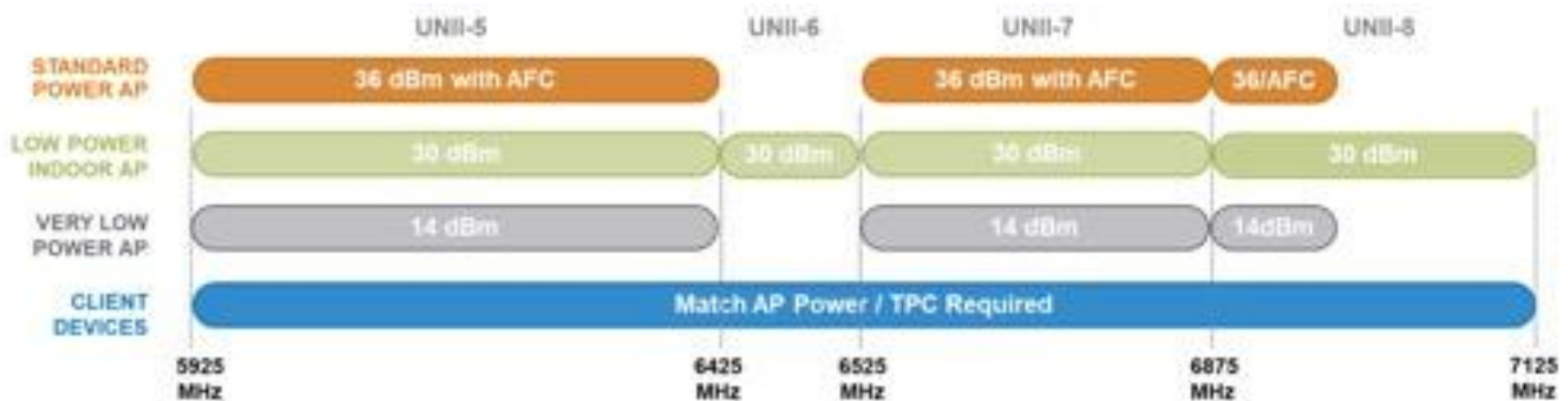
Federal Register / Vol. 83, No. 241 / Monday, December 17, 2018 / Proposed Rules

FEDERAL COMMUNICATIONS COMMISSION

47 CFR Part 15

[ET Docket No. 18–295, GN Docket No. 17–183; FCC 18–147]

Unlicensed Use of the 6 GHz Band



Source: <https://www.govinfo.gov/content/pkg/FR-2018-12-17/pdf/2018-26013.pdf>

License Exempt Spectrum

mmWave

License Exempt Spectrum

Millimetre Wave (mmWave)

	24.05 – 24.25 GHz		57 -64 GHz		64 - 71 GHz		71 – 76 GHz		81-86 GHz	
	EIRP	Tx Power	EIRP	Tx Power	EIRP	Tx Power	EIRP	Tx Power	EIRP	Tx Power
Mexico			82 dBm (if gain less than 51dBi, 2 dBm less TxPower per each dBi below)				85 dBm	35 dBm	85 dBm	35 dBm
South Africa			55 dBm (40dBm up to 66 GHz)	10 dBm						
United States	Gain must be at least 33 dBi	0 dBm	82 dBm (if gain less than 51dBi, 2 dBm less TxPower per each dBi below)		82 dBm (if gain less than 51dBi, 2 dBm less TxPower per each dBi below)					

1.5 Km difference

Source: Innovations in Spectrum Management

https://www.internetsociety.org/wp-content/uploads/2019/03/InnovationsinSpectrumManagement_March2019-EN-1.pdf

End of Part 1

Tomorrow: Access to Spectrum in
Rural Areas