Towards The Personal Ultra broadband Era (Re-imagining Our Wireless World 2020)

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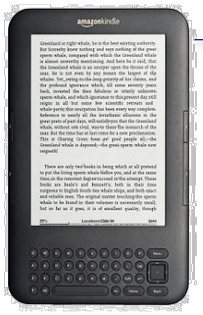
Re-imagination Is The Driving Force Of Innovation Today



Re-imagining how we READ BOOKS

NETFLIX

Re-imagining how we WATCH TV

Re-imagining the NEWS

facebook

Re-imagining our LIFE STORIES

ENGAGEMENT

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stray boots

UBER

GROUPON
Collective Buying Power

APPY COUPLE

C1

karma

Re-imagination of our physical experiences…of our digital economy

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And We Are Only At The Beginning Of This Next Wave

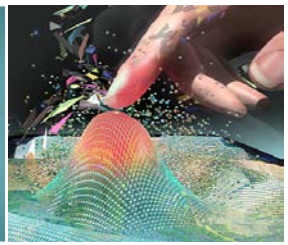


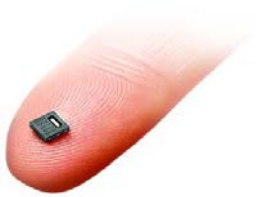
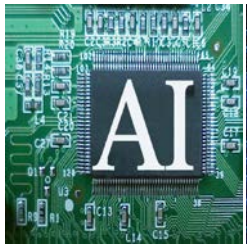



Help | Guide | Entertain | Hear | Protect | See | Sense | Feel | Heal | Smell | Think | Be Me

Principle focus to date





Realizing these “experiences” will push broadband needs to new levels

At InterDigital We Call This The Bandwidth Crunch

Sure, More spectrum & Het Nets are given but this will only be a part of the solution

	Average Speeds[1]	Population Density	Devices/ Person	Busy Hour	Required Area Capacity
2012	0.3Mbps	x 4984/km^2	x 1.20	x 15%	0.26Gbp/s/km^2
2016	2.9Mbps	x 5191/km^2	x 1.40	x 20%	4.2Gbp/s/km^2
2020	30Mbps	x 5477/km^2	x 1.70	x 25%	69.8Gbp/s/km^2

Assuming only the performance of LTE-A today[1]

- In 2016 we might need 317MHz of spectrum
- By 2020 we might need more than 5GHz!

Solution will be an ever more complex & “meshy” network of networks

[1]Cisco VNI 2012 [2] 3GPP TR 36.913 (Microcellular model: 2.6b/s/Hz/Cell, ISD=500m, 4x2MIMO) – Assumes perfect trunking efficiencies

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InterDigital Communications Research: What We Do

InterDigital develops fundamental wireless technologies that are at the heart of **mobile devices**, **networks**, & **services** worldwide.

Our technology is used in **all 2G**, **3G, LTE** devices providing support for **new mobile broadband** & **richer multimedia** experience

As a **long time contributor** to the wireless industry, we have solved many of the most **critical** mobile challenges **for 30+ years**

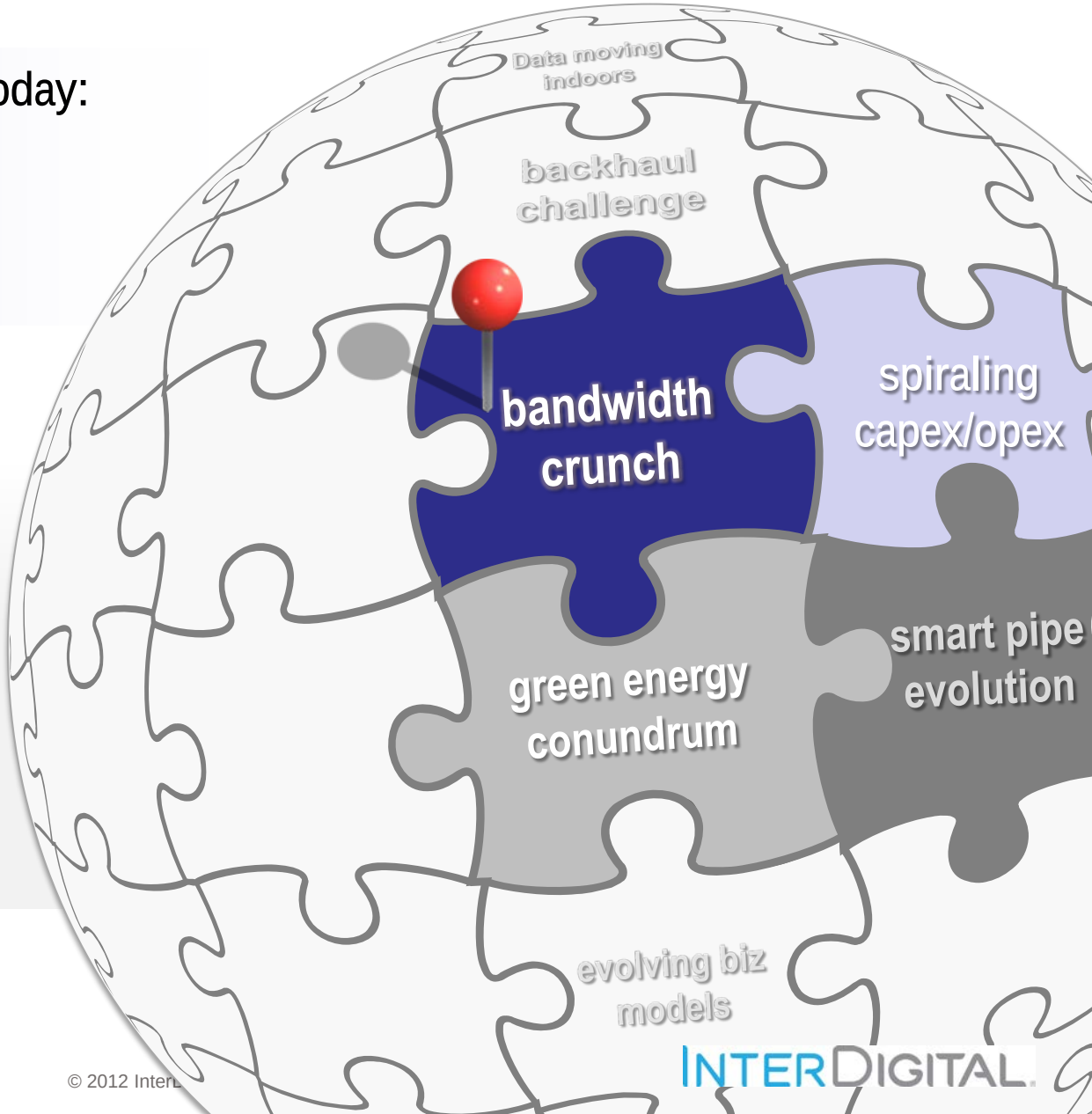
We offer our technologies to the market in **IP blocks** and **full product** solutions and have been **key** in high profile OEM offerings

InterDigital has been tackling the bandwidth crunch for generations

Today's Challenge is More Complex than Ever

Service Provider Options Today:

- Ration resource usage
- Invest in new capacity
- New revenue innovation



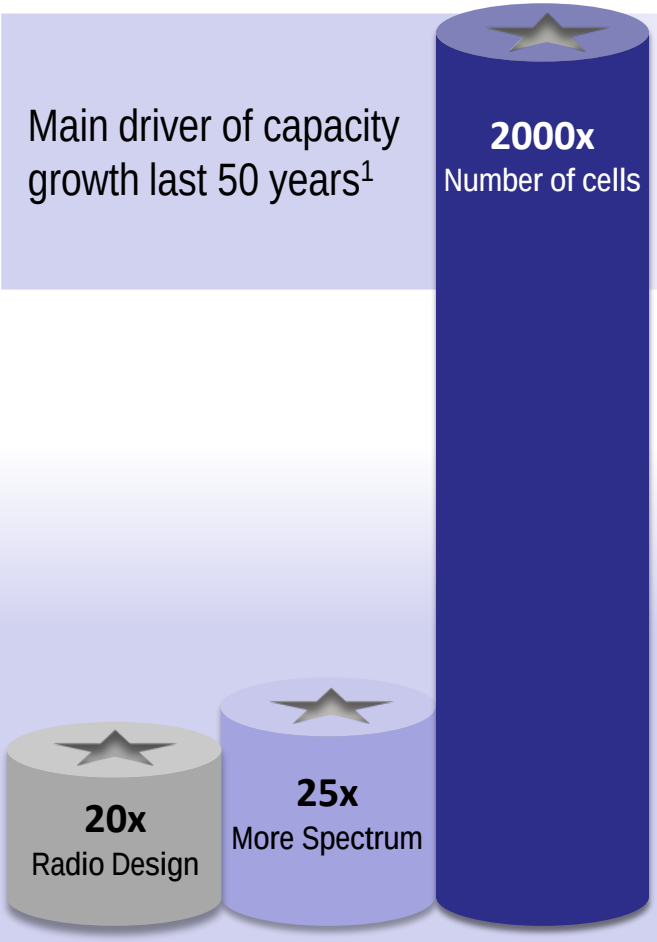
And Tomorrow?

Two tech trends will perhaps shape future more than any

The Relentless Move To Small & Smaller Cell Solutions

It has always been about making the network more efficient and smarter

Main driver of capacity growth last 50 years[1]



Broadcast → Cellular → Microcell, Picocell → Nano, Femto, WiFi → Ultra-dense, Device2 Device, THz Cells

This is unlikely to change anytime soon

- **Next step:** cooperative ultra-dense cell technology that opportunistically leverages licensed/unlicensed
- Cellular controlled Device2Device communications: Our research shows time is right for this technology
- And beyond: Falling device cost & wealth of spectrum will drive THz move for "indoor & around" applications (3.5GHz⇨5GHz⇨10GHz⇨20GHz ⇨60Hz ⇨⇨⇨)

All driving us to a world of ubiquitous connectivity asset availability

[1] Source: Agilent, 2008 (Coopers Law)

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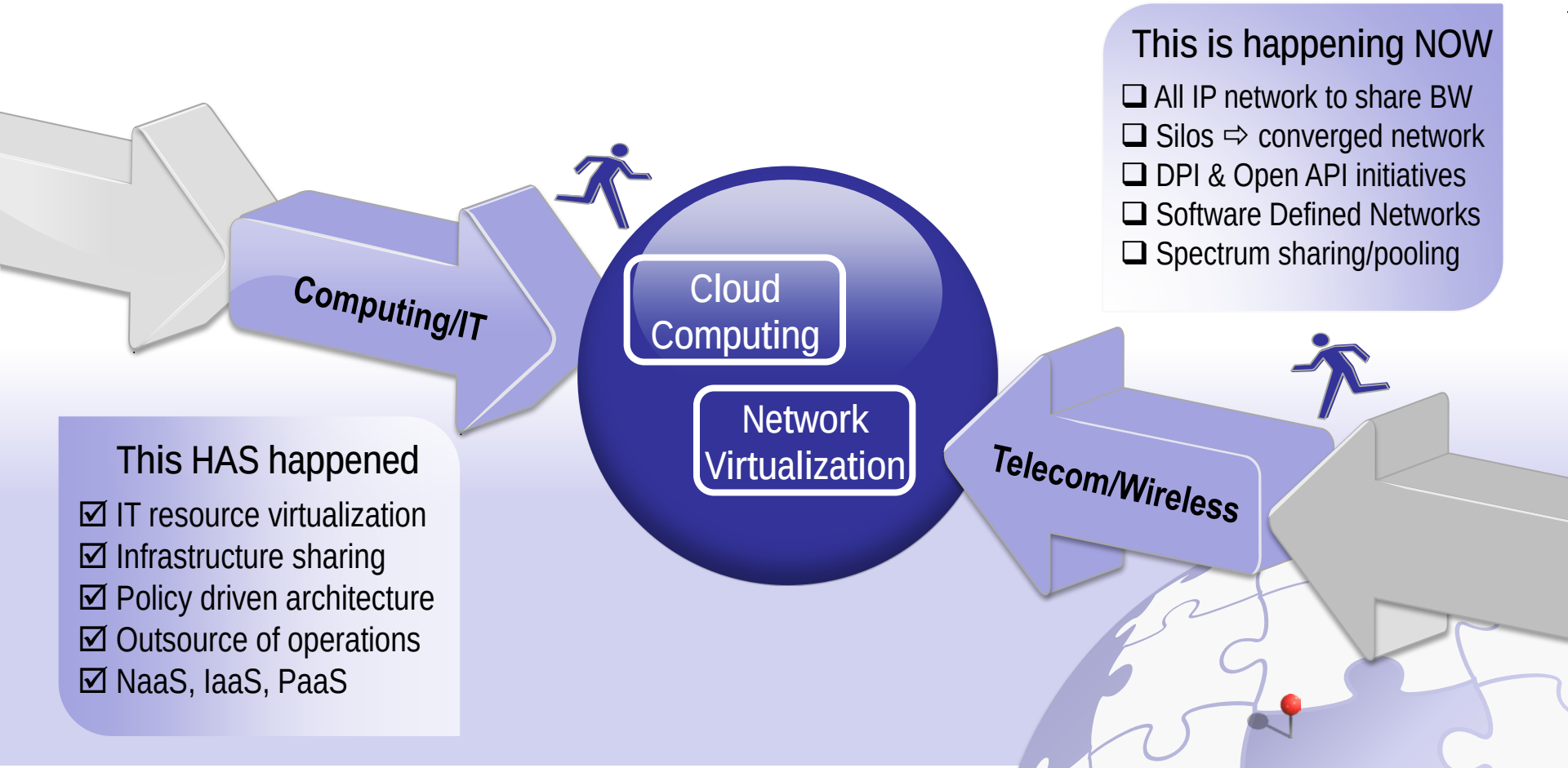
The Cloud *or* Increasingly Pervasive Sharing Technology

Commonplace in the computing industry; Telecom/Wireless is playing catch-up



"Virtualization" at all levels will be critical to defeating the BW crunch

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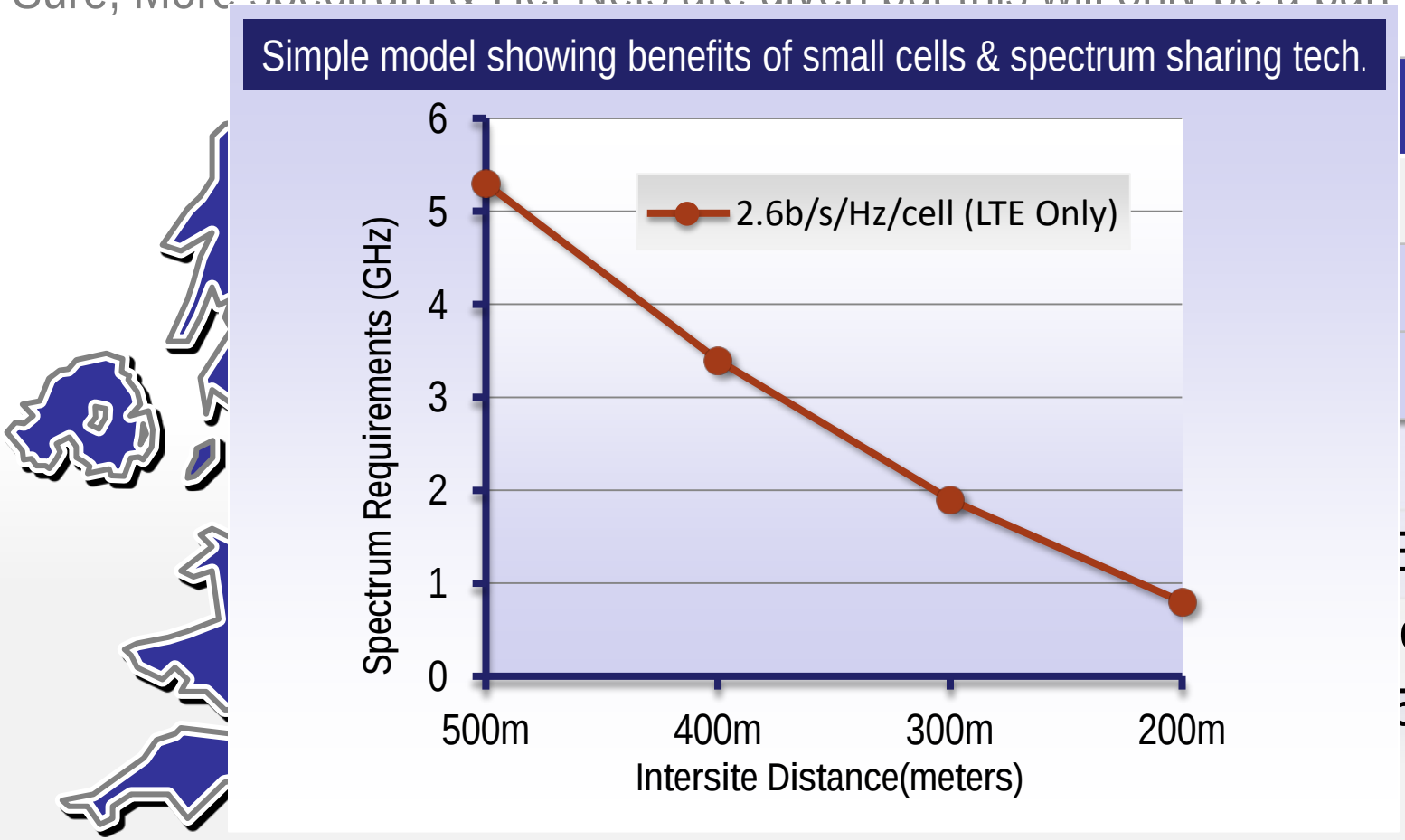
In Illustration: Aggregate Effects Will Be Quite Profound

Sure, More spectrum & Het Nets are given but this will only be a part of the solution



Required Area Capacity
0.26Gbp/s/km^2
4.2Gbp/s/km^2
69.8Gbp/s/km^2

E-A today[2]

ectrum

5GHz!

Nothing “dumb” about this future; Making it work will be the challenge

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Putting This All Together: A Future Vision Emerges

2G	3G	4G	Beyond 4G
Narrowband era	Broadband era for few	And for the masses	Personal Ultra Broadband Era

Future direction indicators:

- Emergence of a world of ubiquitous access resource availability
- The rise of the cloud and network sharing/virtualization paradigms
- Broad new innovative thinking in spectrum usage & application
- Ever more powerful, multifunctional, multi-resource user devices

Glimpses of This Future in Today's Emerging Tech.

Aggregation, sharing & flexibility is the new normal

- Multi-Operator spectrum sharing is becoming more common
- IEEE is driving new standards[1] in shared use spectrum access
- Small cell trend pushing cellular into *wifi* spectrum & vis-a-vis

No longer WiFi vs. Cellular it's all about application

- Carrier grade WiFi development[2] now blurring historical divides
- Flow seg. & IP flow mobility re-imagining offloading paradigm
- Future will see tight integration of technologies @ MAC layer

Devices are "talking" to each other in different ways

- P2P media sharing emerging as common smartphone feature
- WiFi Direct & "Proximity services" skewing device|access lines
- M2M & IoT emerging as a critical new carrier revenue streams

[1] IEEE 802.11af enables WiFi secondary use in TV Whitespace spectrum 2 WFA Hotspot 2.0 initiative

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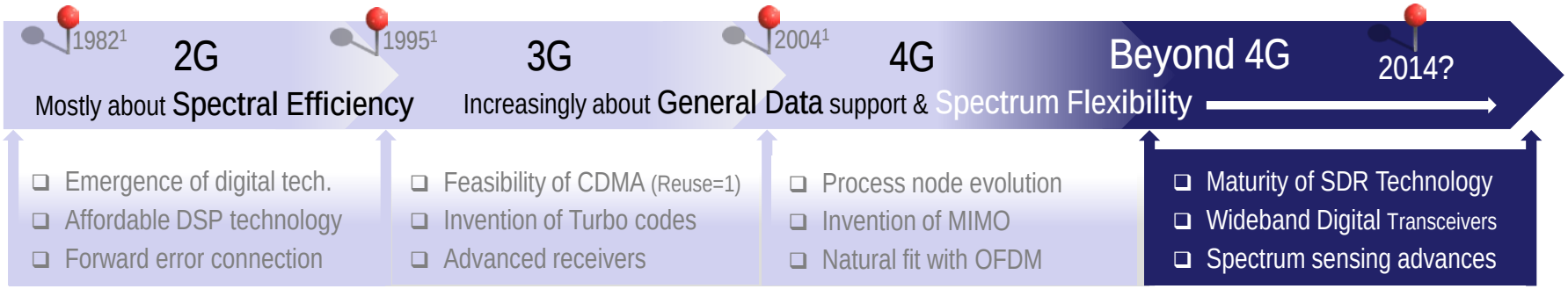
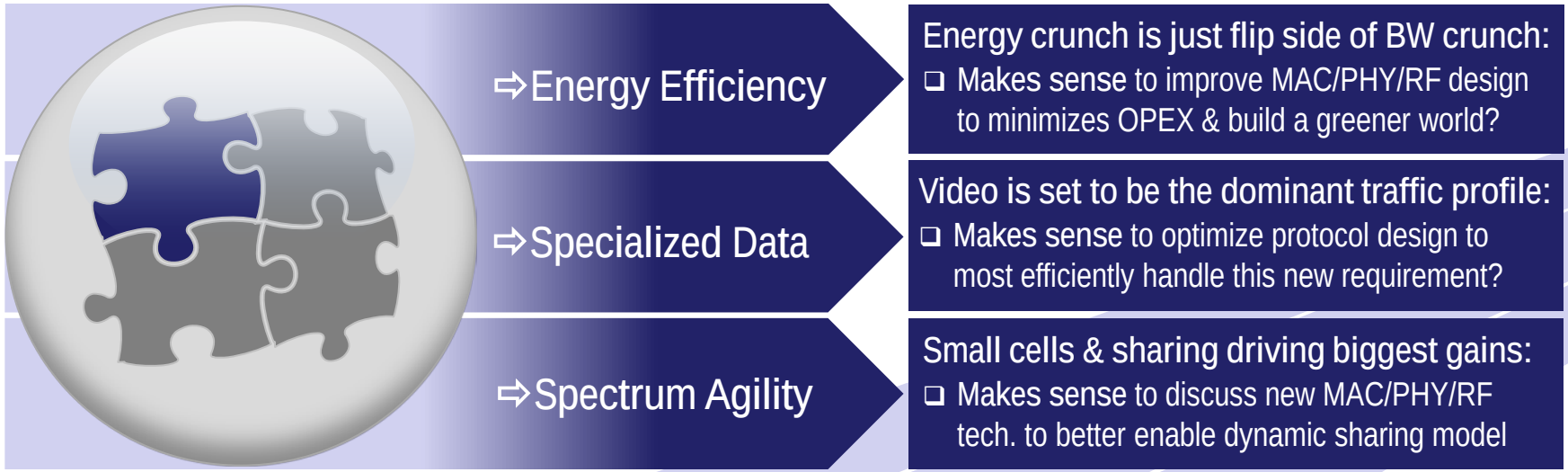
Roadmap May Lead Us To New Air Interfaces (LTE-B,C?)



Likely air interface drivers beyond 4G:

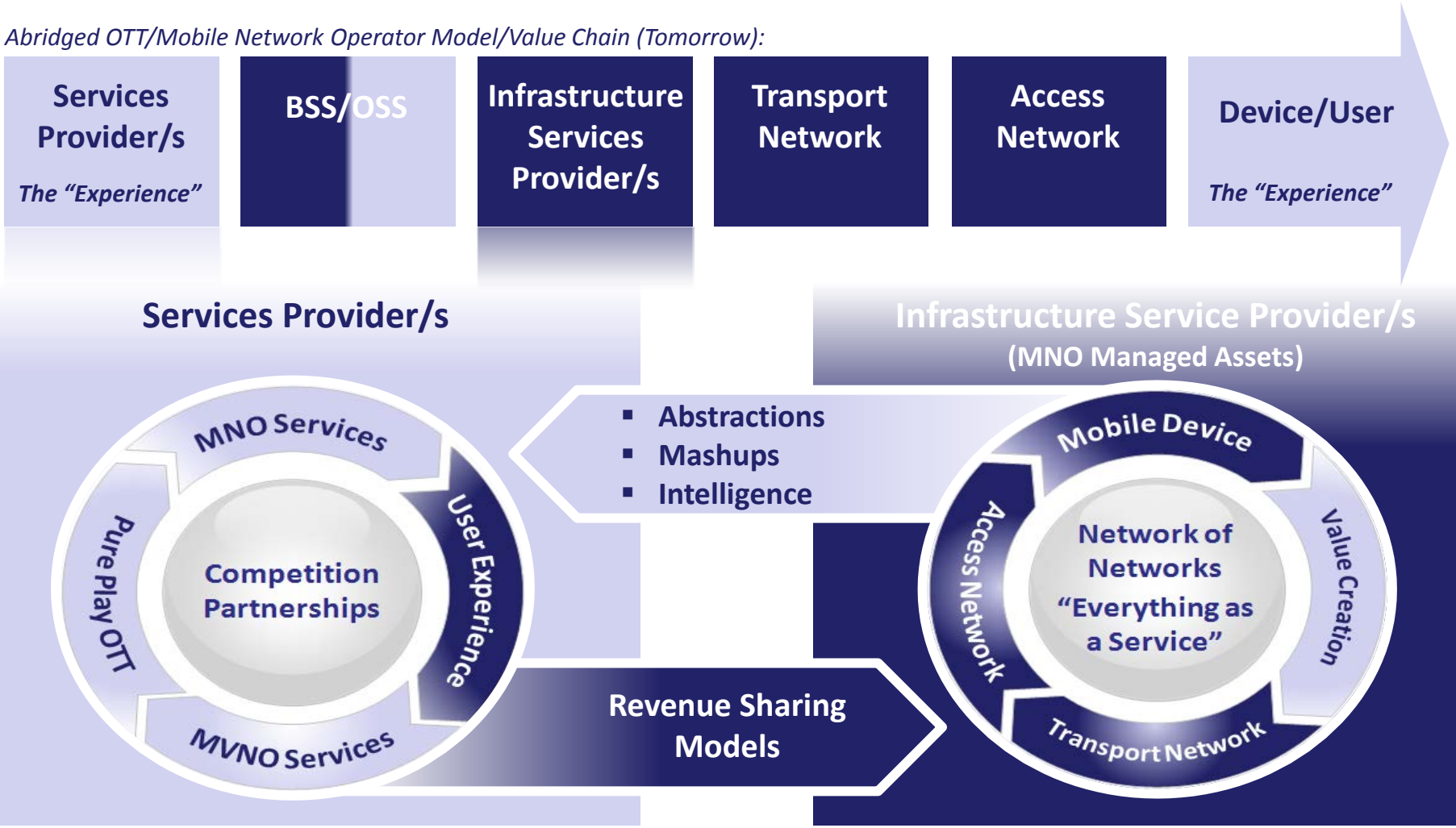


As before it will be a complex question of timing, drivers & enablers

[*] In 1982 CEPT forms GSM, In 1995 UMTS task force kicks off 3G, in 2004 first LTE RAN workshop

...And Maybe New, Better Business Models

Abridged OTT/Mobile Network Operator Model/Value Chain (Tomorrow):



Many questions, many challenges to building this future, this vision

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We Are Asking These Questions & Building this Future Today

Some of our research & development activities in our labs (available today)

Cellular – WiFi Virtualization

A first step in pushing virtualization down to the client. Smart e2e traffic shaping & control over cellular & WiFi technologies

Dynamic Spectrum Management

Policy driven spectrum mgmt. Demonstrating capacity enhancement benefits of operating WiFi & LTE in white space & UL bands

Device-to-Device Technology

Proving that the crowd resource can be leveraged into a virtual resource fabric for performance & social networking benefits

Machine-to-Machine Communications

A lightweight, unified M2M service layer solution that opens clean API that enable many new revenue application potential

Technology solutions for the bandwidth crunch today & tomorrow

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