



# WIRELESS ACCESS FOR THE FUTURE NETWORKED SOCIETY

Erik Dahlman  
Senior Expert  
Ericsson Research

# WIRELESS ACCESS OF TODAY

*TODAY ...*



*The foundation of  
mobile telephony*

**1G**

NMT  
AMPS  
TACS

*Mobile telephony  
for everyone*

**2G**

GSM  
IS-136  
PDC  
IS-95

*The foundation of  
mobile broadband*

**3G**

WCDMA/HSPA  
cdma2000  
TD-SCDMA

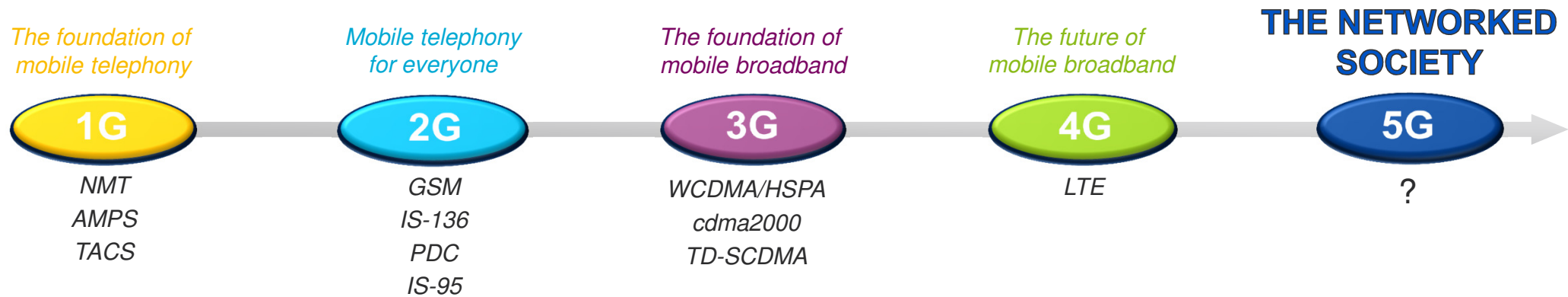
*The future of  
mobile broadband*

**4G**

LTE

# WIRELESS ACCESS TECHNOLOGY

*TODAY ... AND IN THE FUTURE*



# THE NETWORKED SOCIETY

IN THE NETWORKED SOCIETY PEOPLE,  
KNOWLEDGE, DEVICES, AND INFORMATION  
ARE NETWORKED FOR THE GROWTH  
OF SOCIETY, LIFE, AND BUSINESS



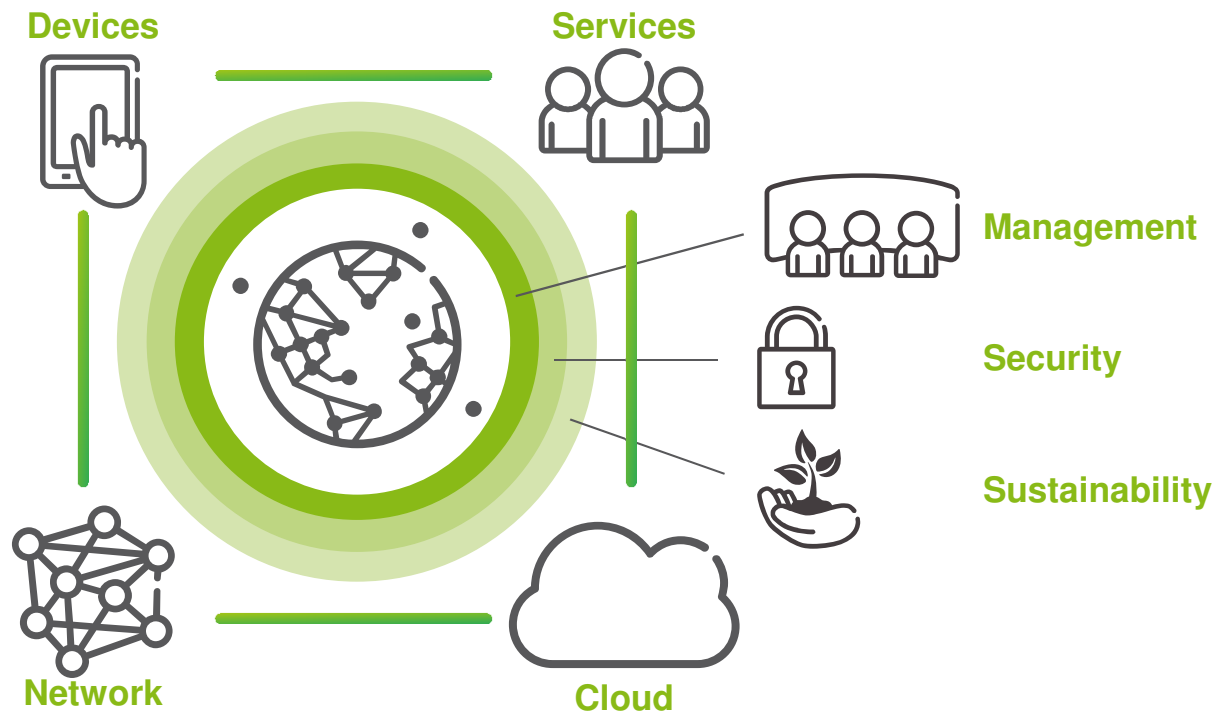
# THE NETWORKED SOCIETY



*Unlimiting access to information and sharing of data  
anywhere and anytime for anyone and anything*

*Anything can be connected!*

# THE NETWORKED SOCIETY



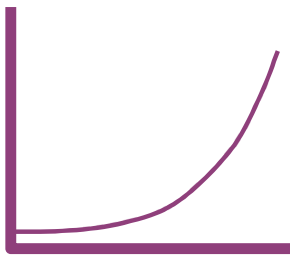
Wireless Connectivity  
is key

# FUTURE WIRELESS ACCESS

## KEY CHALLENGES



### Massive growth in Traffic Volume



“1000x and beyond”

### Massive growth in Connected Devices



“50 billion devices”

### Wide range of Requirements & Characteristics

- Data rates
- Latency
- Reliability
- Device energy consumption
- Device cost
- .....



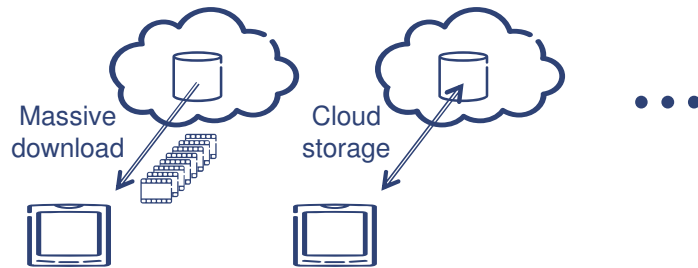
**Affordable and sustainable**



# DATA RATES?



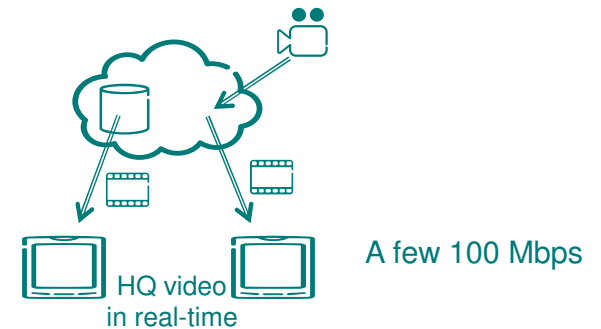
How much is enough?



*No upper limit!*

**A few 10 Gbps in specific scenarios**

What do I really want?



*Essentially everywhere!*

**A few 100 Mbps generally available**



# COMMUNICATING MACHINES



- › Very low latency ... *in some cases*
- › Very high reliability ... *in some cases*
- › Very small payloads ... *in some cases*
- › Very good coverage ... *in some cases*
- › Very low device cost ... *in some cases*
- › Very long battery life ... *in some case*

⋮



Consumer Applications



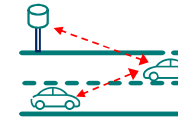
Logistics



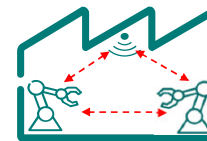
Smart metering



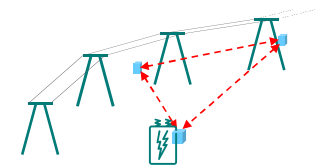
Surveillance



Traffic safety/control

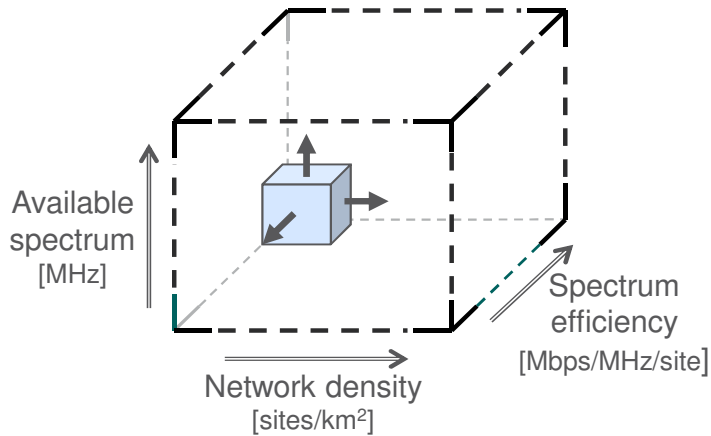


Industrial applications



Smart grids

# TRAFFIC CAPACITY



$$\text{Traffic capacity [Mbps/km}^2\text{]} = \text{Available spectrum} \times \text{System efficiency}$$

*System efficiency*  
Network density × Spectrum efficiency

- › More spectrum, preferably of high quality
- › More dense network infrastructure (including more antennas)
- › Smart cooperation between network nodes

# SPECTRUM



Spectrum is key to what we do ... and there is never enough!

**Today – *Spectrum up to 3.5 GHz***



# SPECTRUM



**Up to 2020** – *Extended spectrum availability up to  $\approx 6.5$  GHz*



# SPECTRUM



## Beyond 2020 – *Extension beyond 10 GHz*



- › Large amount of spectrum available ⇒ Further massive increase in traffic capacity
- › Potential for very large bandwidths ⇒ Enabler of extreme data rates
- › Small wave length ⇒ Enabler for massive antenna solutions
- › **But still issues to resolve!**

# NEW WAYS OF USING SPECTRUM

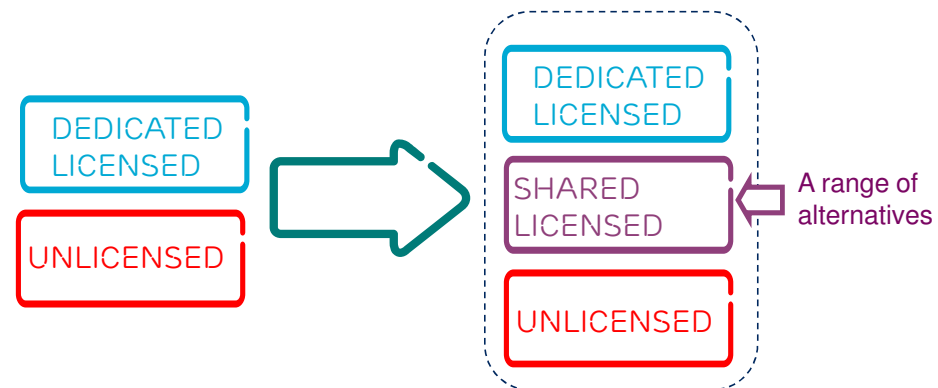


- > **Cellular:** Highly coordinated licensed dedicated spectrum
  - Guaranteed availability but potentially inefficient at low load
- > **WiFi:** Shared nlicensed spectrum with no coordination/control
  - Efficient at low load but unreliable/in-efficient at high load

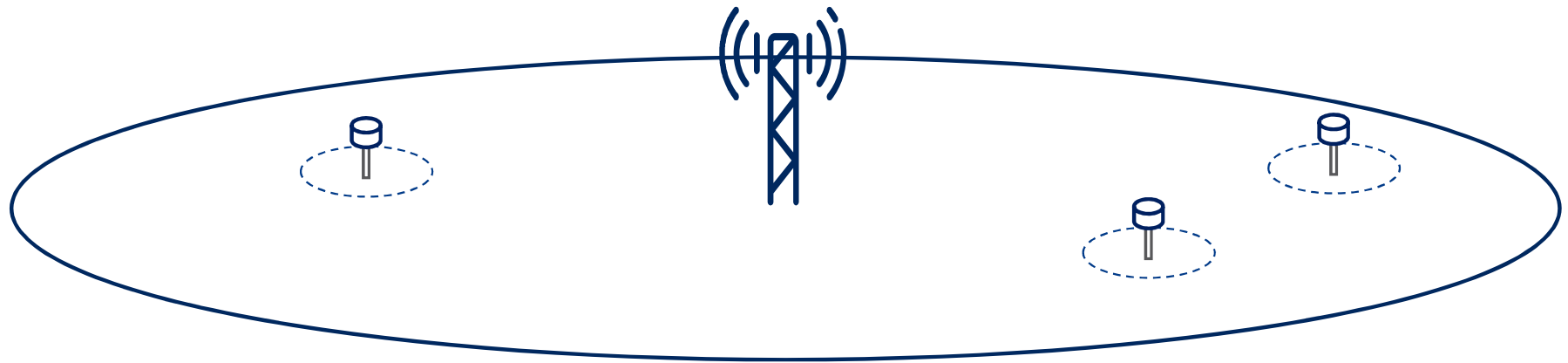
## Future: Consider a range of spectrum-access means

- Licensed but shared
- ...

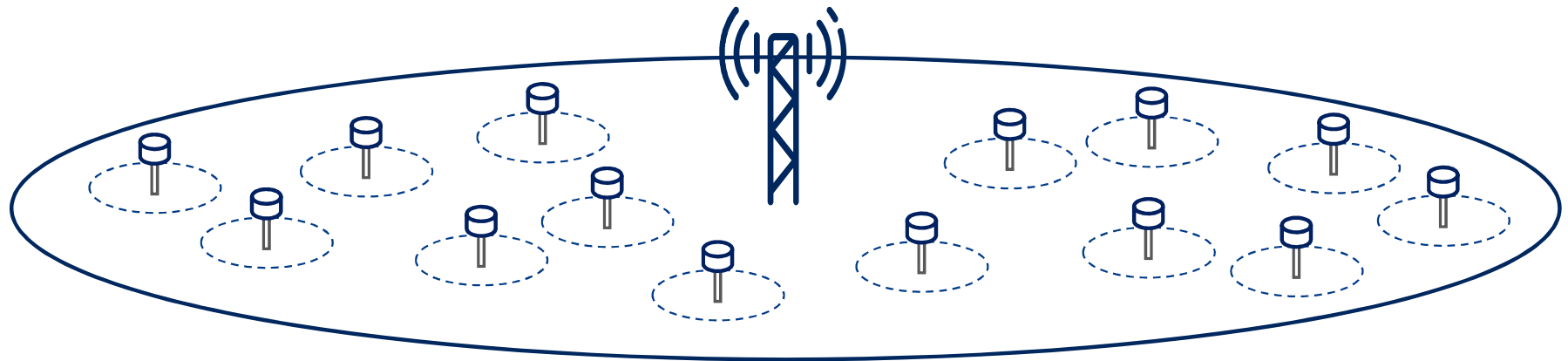
Complement to dedicated licensed spectrum



# DENSE NETWORKS



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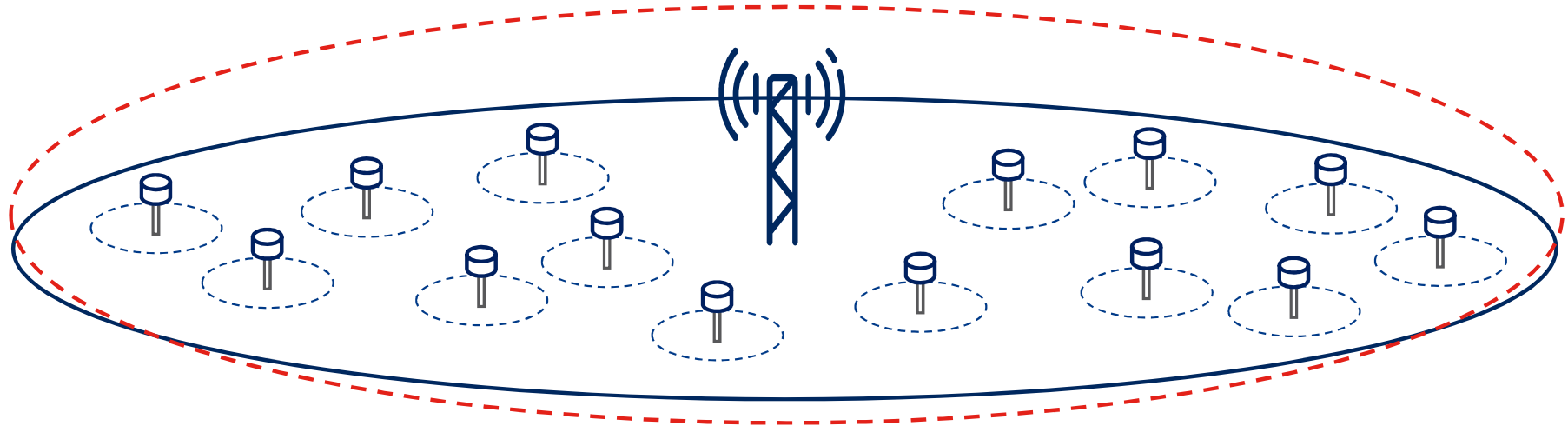




# DENSE NETWORKS



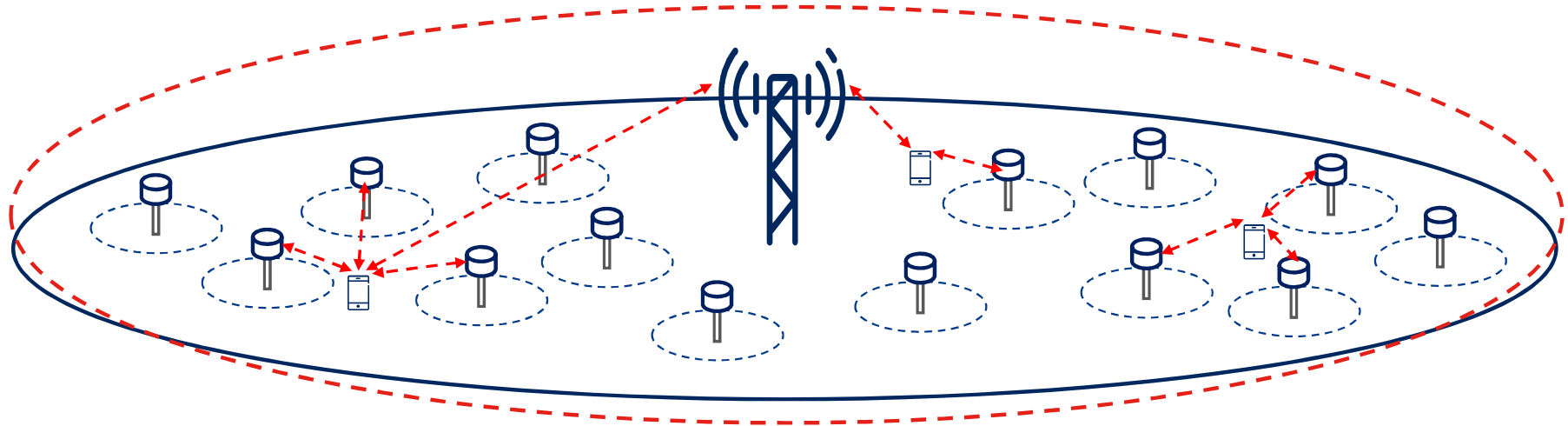
Integrated operation



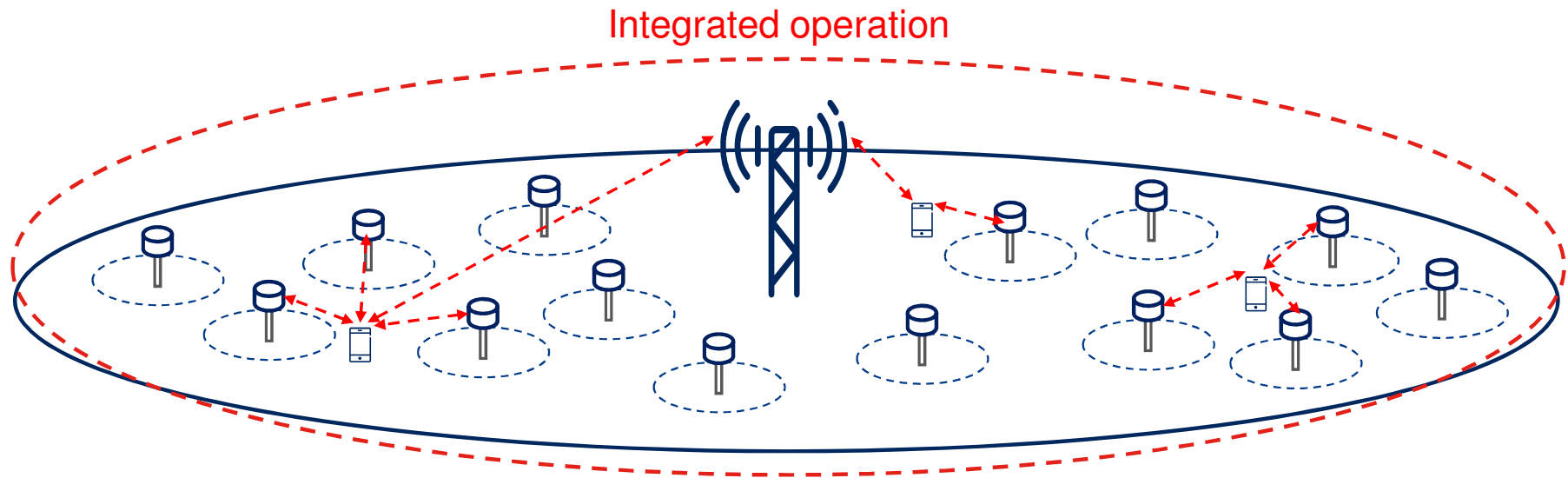
# DENSE NETWORKS



Integrated operation



# DENSE NETWORKS

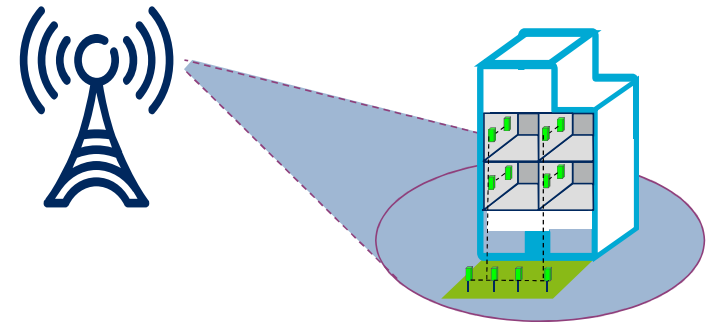


- › Must ensure simple low-cost deployment!
- › Must ensure backhaul availability!

# ULTRA-DENSE DEPLOYMENTS



- › Orders of **magnitudes denser** than any cellular network of today
- › GHz bandwidth at very high frequency bands



- › Smooth inter-working with wide-area networks
- › Need for flexible backhauling including wireless self-backhaul

# WHAT IS 5G?



# WHAT IS 5G?



2G could do everything  
that 1G could do  
... and somewhat more  
... and somewhat better

# WHAT IS 5G?



3G could do everything  
that 2G could do  
... and somewhat more  
... and somewhat better

# WHAT IS 5G?



4G can do everything  
that 3G could do  
... and somewhat more  
... and somewhat better



# WHAT IS 5G?



A single new technology that can  
do everything that 4G can do

... and somewhat more

... and somewhat better

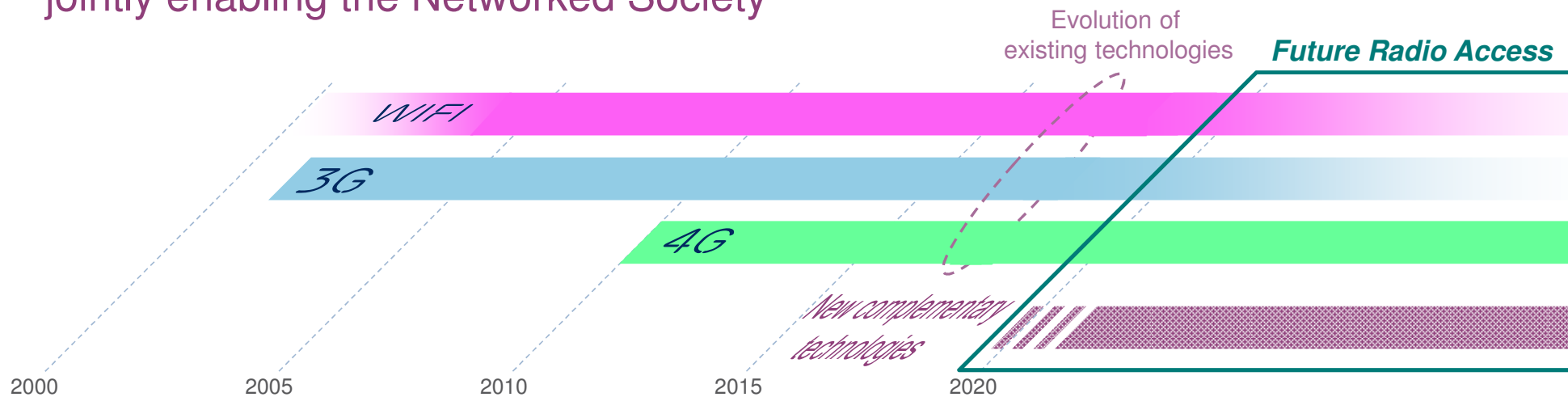


*Or should we consider a different approach this time?*

# FUTURE RADIO ACCESS – 5G



A set of integrated radio-access technologies jointly enabling the Networked Society



- › Evolution of existing radio-access technologies
- › New *complementary* technologies

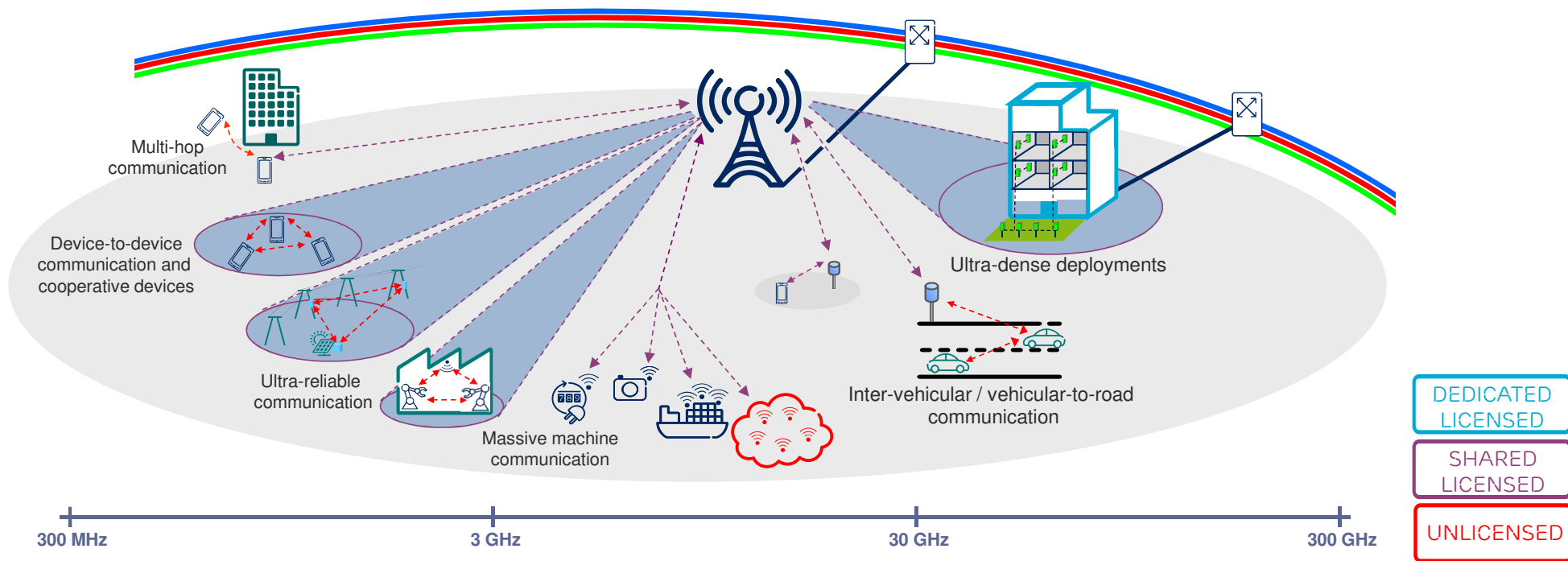


*New technology components needed in both cases*

# FUTURE RADIO ACCESS



A set of integrated radio-access technologies jointly enabling the Networked Society

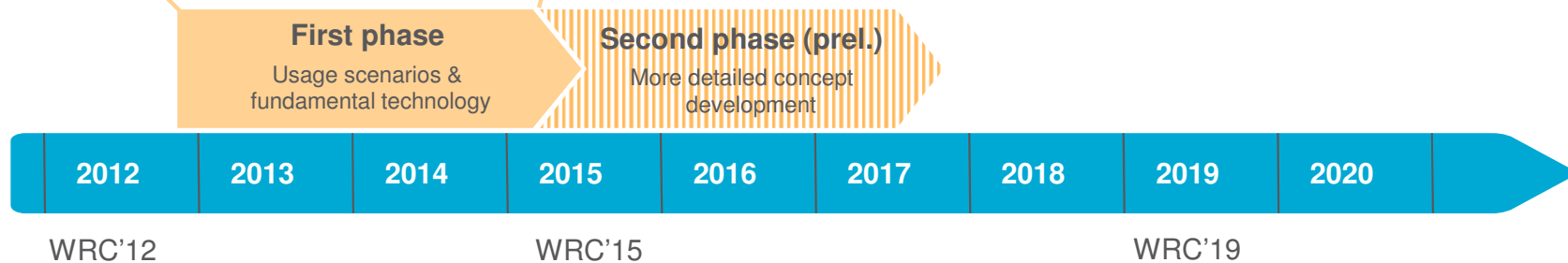


# METIS PROJECT

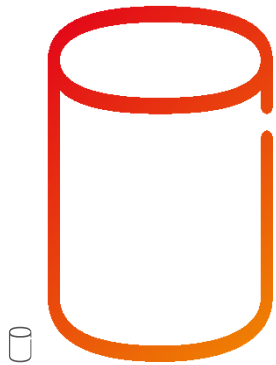


EU-funded research project on future wireless communication

29 partners / ≈2500 man-month / 29 M€



# METIS PROJECT OBJECTIVES



1000x

higher mobile data volumes



10-100x

higher number of connected devices



10-100x

typical end-user data rates



5x

lower latency



10x

longer battery life for low-power devices

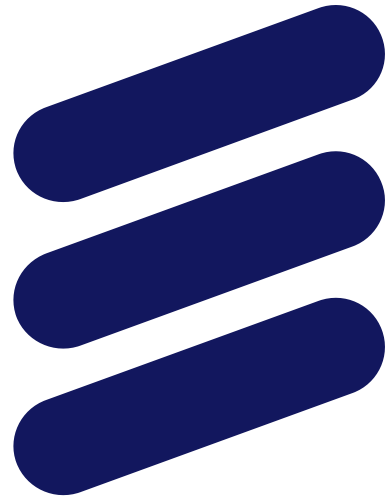
Develop a concept for future mobile and wireless communications system that supports the connected information society

# FUTURE WIRELESS ACCESS



- › A key enabler for the Networked Society
- › Key challenges
  - Continued traffic growth
  - Massive machine communication with wide range of requirements and characteristics
  - Cost and energy consumption
- › Evolution of existing wireless technologies
- › New complementary technologies
- › Research on "5G" has started





**ERICSSON**