Designing Sustainable Infrastructure for Ubiquitous Edge

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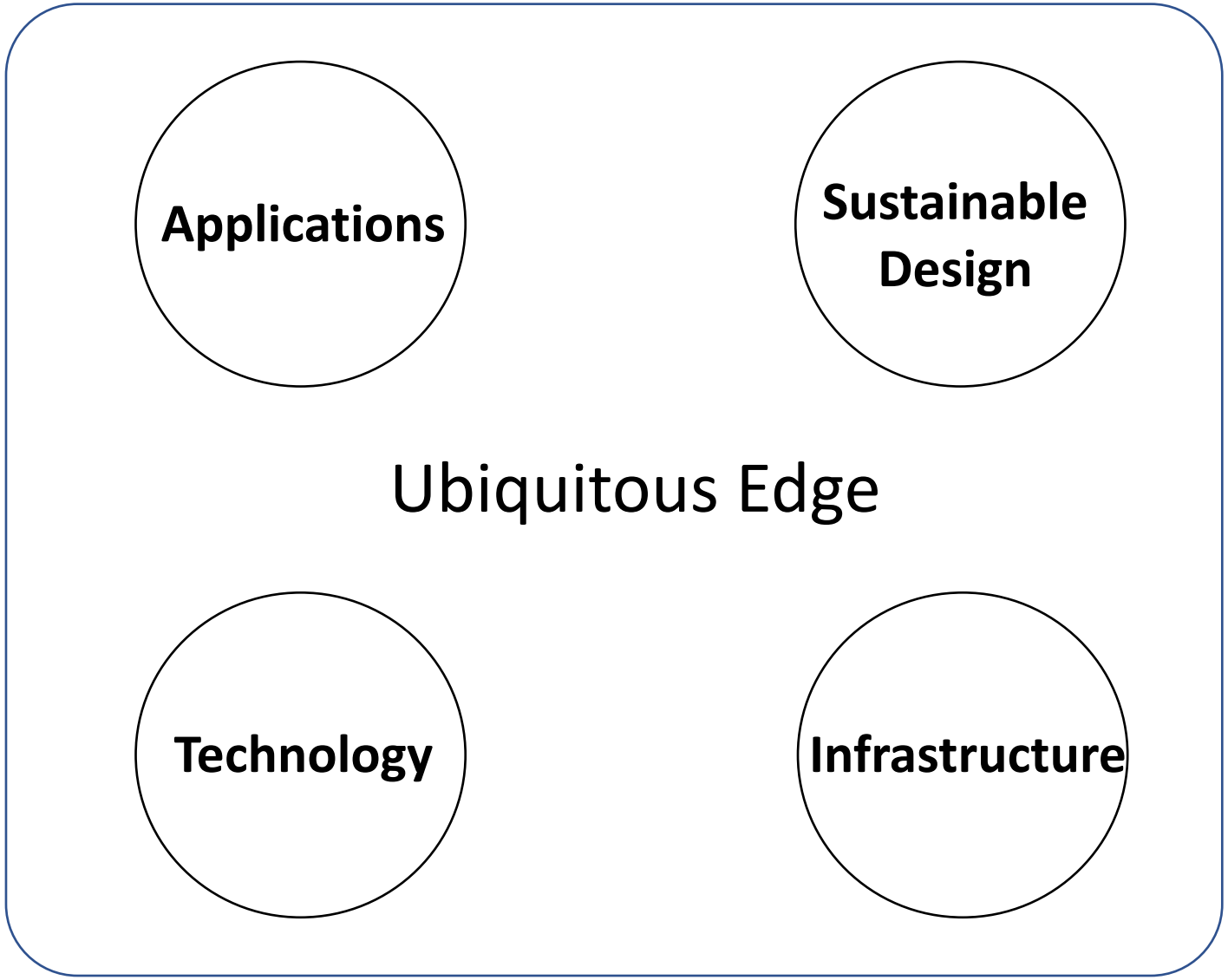
These must be related…



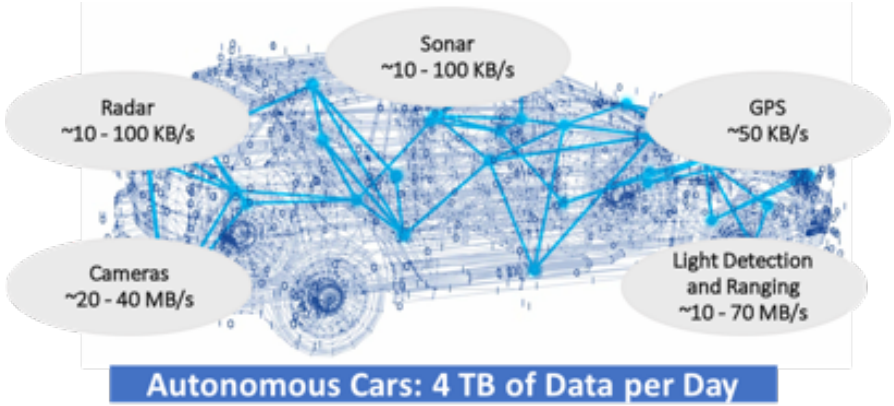
u·biq·ui·tous

/yo͞o ˈbikwədəs/

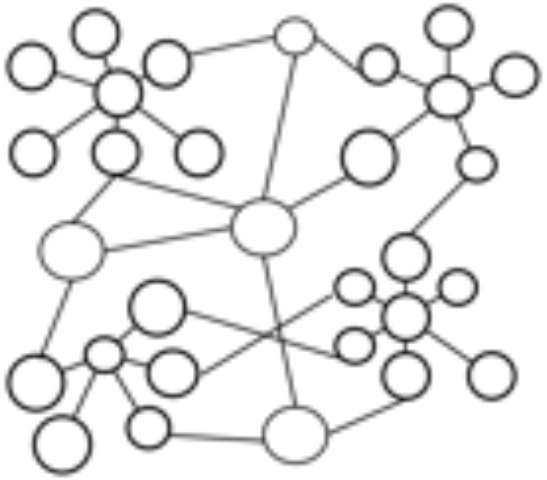
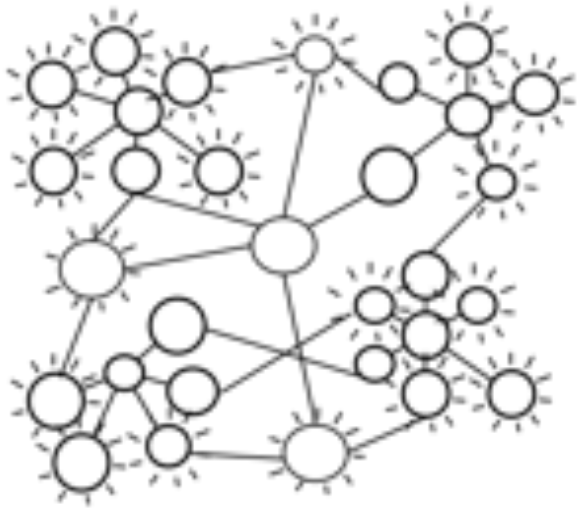
adjective

present, appearing, or found everywhere.

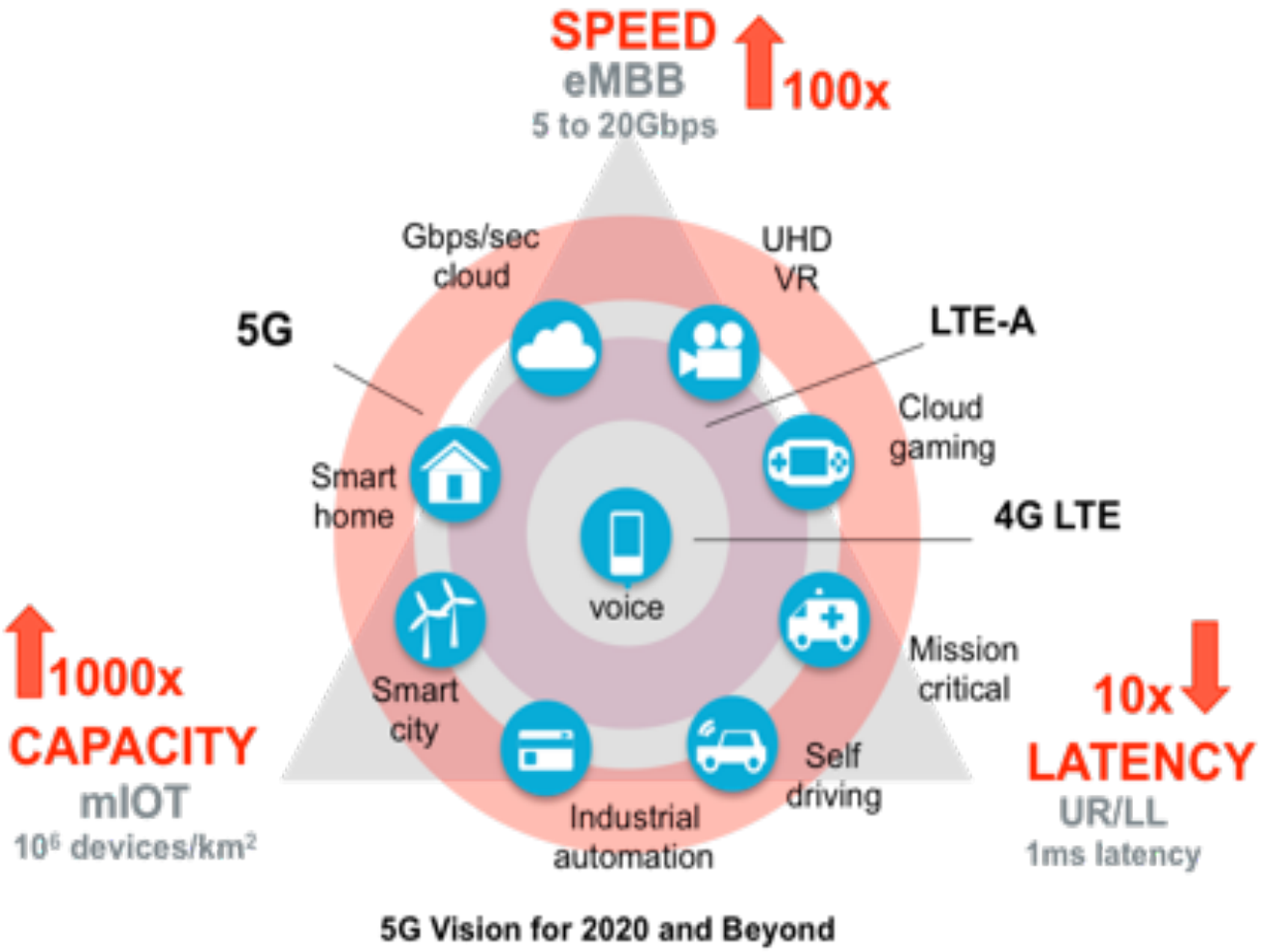
New requirements are driven by more and more data and Edge expansion



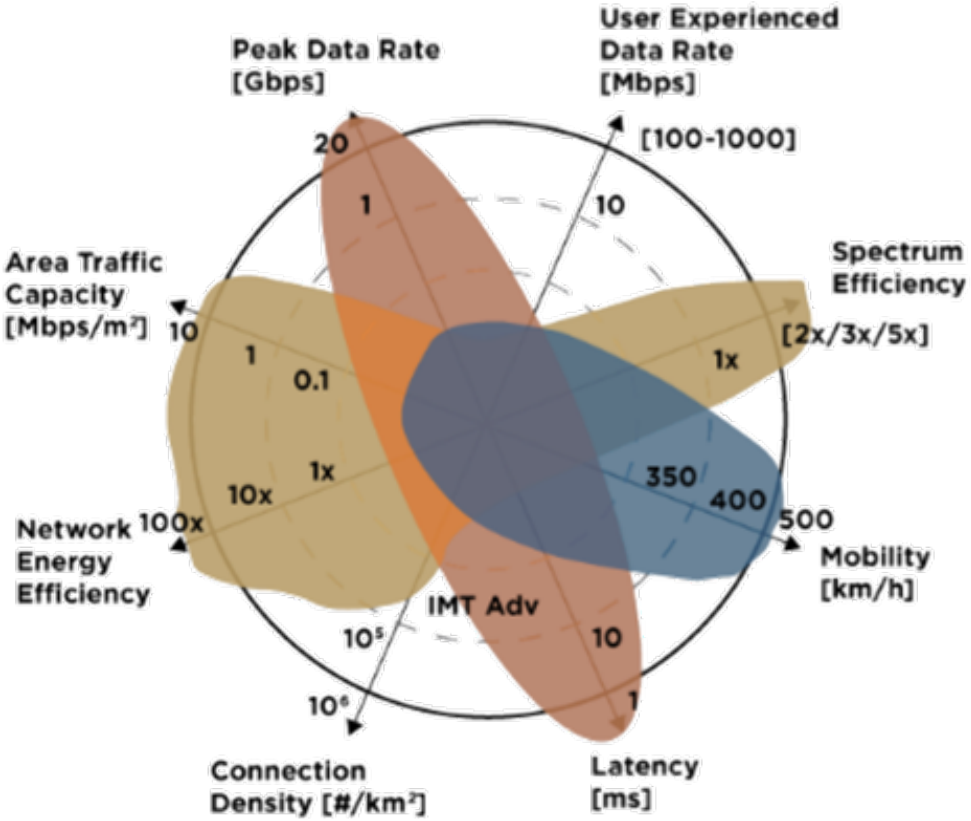
New applications drive expansion to the edge and densification of networks

Legacy	Existing	Forming
Hub and Spoke	Distributed	Cloud and Edge
		
User to App Distance	~ 10^{3} km ~ 10^{-1} sec	~ 10^{2} km ~ 10^{-2} sec	~ 10^{1} km ~ 10^{-3} sec

5G Characteristics and Use Cases

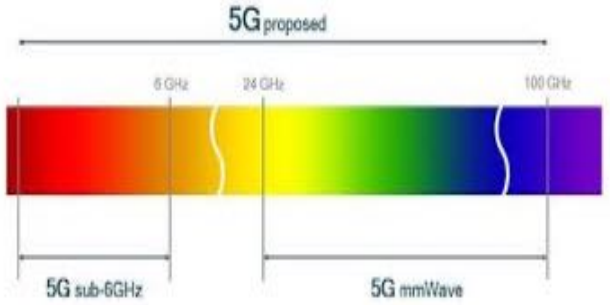


5G Vision for 2020 and Beyond



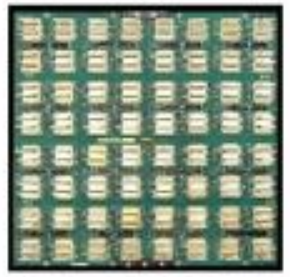
Key technologies behind 5G

New Spectrum and mmWave



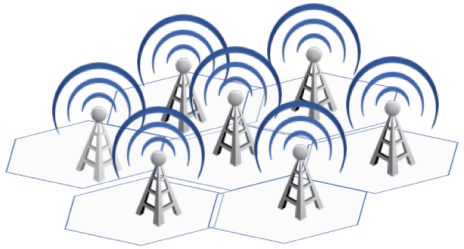
- New 6-100 GHz Spectrum
- mmWave (> 28 GHz)
- Wide Bandwidth (100s of MHz to 1 GHz)
- Shorter Reach (~500 meters)

Massive MIMO



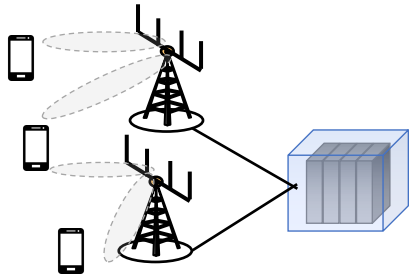
- Hundreds of antennae elements in an array
- Precision beamforming
- Multiple transmission layers and channels

Small Cells and Dense Fiber



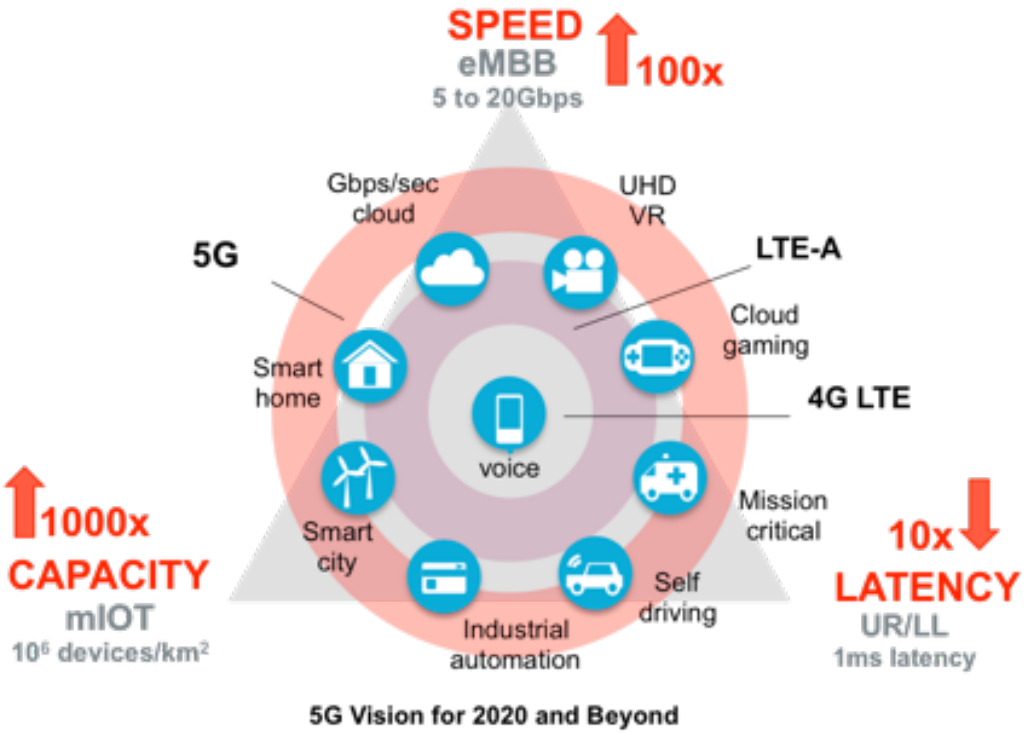
- Small Cells (radius < 500 meters)
- Cloud and Virtualized Radio Access Network
- Dense deployment
- Fiber to each cell

Beamforming and Beamsteering



- Focused, narrow radio beams (~10 degrees)
- High efficiency and low interference
- Digitally focused and tracking using MIMO

Edge Infrastructure and Technology Drivers



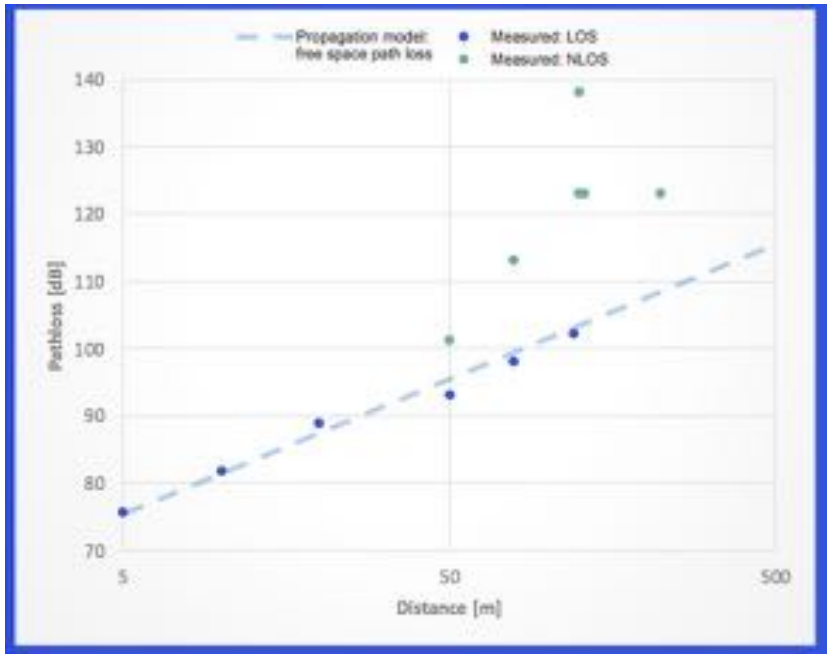
5G Vision for 2020 and Beyond

Technology Driver	Significance
Massive densification of Radio Access Network	Small Cell deployments. Increase of spectral efficiency from Bit/Sec/Hz to Bit/Sec/Hz/km^2
Disaggregation of Radio Access Network – Cloud and Virtual RAN	C/V-RAN requires aggregation and compute resources Baseband functionality is Virtualized Network Function
Virtualization of Mobile Core – Virtualized Packet Core	vEPC requires Private/Public Cloud compute and network infrastructure
Multi-access Edge Computing (MEC)	Ultra Reliable and Low latency (UR/LL) IoT services, Virtual/Augmented Reality (VR/AR) will require MEC
Need for dense fiber infrastructure	Small Cell, Fronthaul and Data Center connectivity
Need for infrastructure at the edge	Micro Edge Data Centers

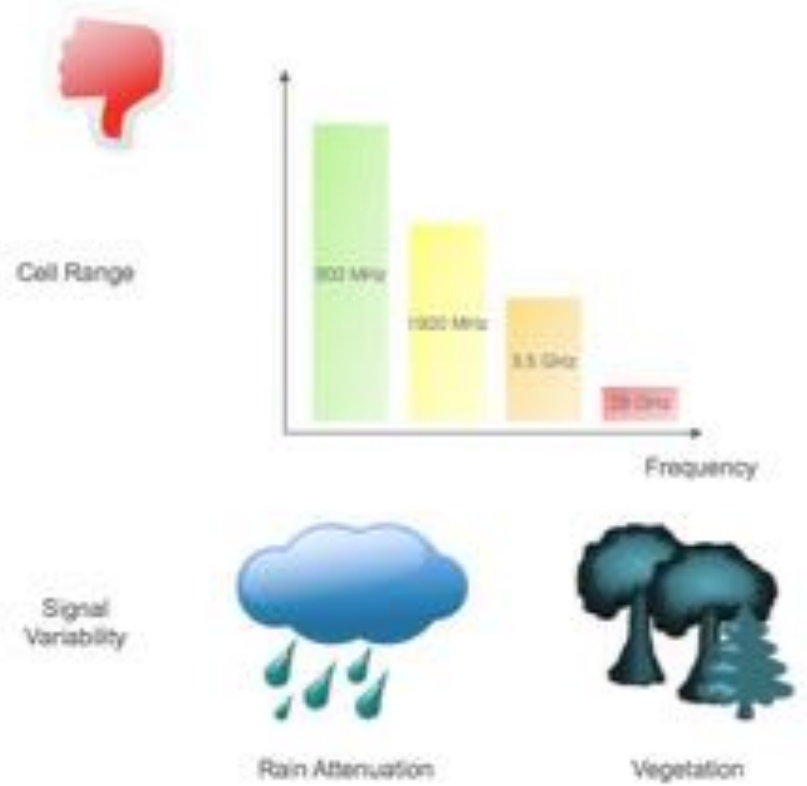
High performance comes at a price – decreased transmission range

$$P_r = \frac{P_t G_t G_r c^2}{(4\pi R f)^2}$$

Friis Transmission Equation
(reverse relationship between frequency and received radio energy)



mmWave Path Loss Model – 5G NR Cell radius < 150 m
(mix of Line of Sight (LOS) and Non-Line of Sight (NLOS) propagation)



Source: Infovista 5GNR Planning Webinar

Capacity requirements drive further densification

Spectral Efficiency, Bit/sec/Hz

Radio Site Density, 1/km^2

User Density, 1/km^2

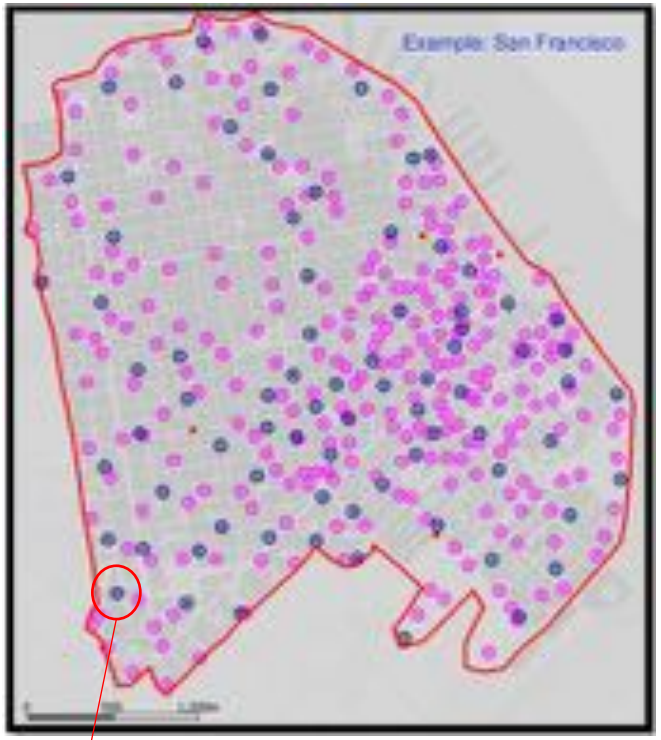
Radio Transmit Power, Watt

Noise and Interference Power, Watt

$$\bar{R}_{\Phi_1}\left(\lambda_1, \lambda_0, P_{\mathrm{Tx}}, \sigma_{\mathrm{N}}^2\right) =$$

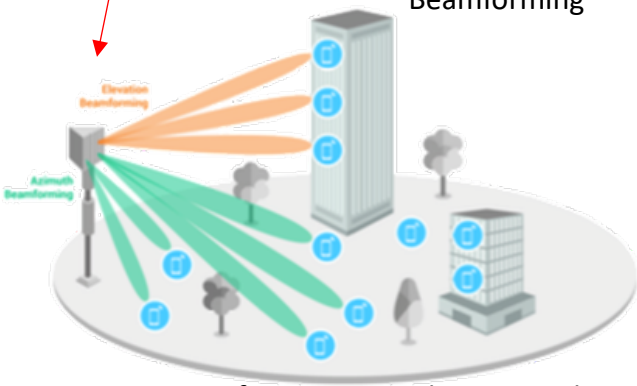
$$\frac{\pi^{5/2}}{2}\sqrt{\frac{\lambda_0\lambda_1 P_{\mathrm{Tx}}}{\sigma_{\mathrm{N}}^2}}\,\mathrm{Erfc}\left[\frac{\pi^2\lambda_0}{4}\sqrt{\frac{P_{\mathrm{Tx}}}{\sigma_{\mathrm{N}}^2}}\right]\exp\left[\frac{\pi^4\lambda_0^2 P_{\mathrm{Tx}}}{16\sigma_{\mathrm{N}}^2}\right]$$

[1] Are Heterogeneous Cloud-Based Radio Access Networks Cost Effective? Vinay Suryaprakash, Member, IEEE, Peter Rost, Senior Member, IEEE, and Gerhard Fettweis, Fellow, IEEE.



Source: Qualcomm, Best Practices for Deploying 5GNR Networks

Radio site density is further increased
Due to the need to plan for 3D coverage
Beamforming

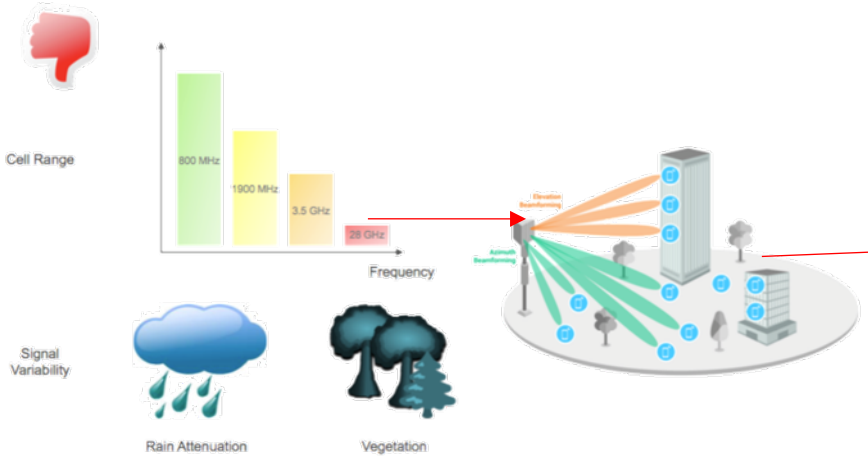


Source: Infovista 5GNR Planning Webinar

To maintain high spectrum efficiency (i.e., to deliver 100s of Mbps per user), given expected user densities of 150 – 200 users/km^2, the model yields radio site densities on the order of 50 – 100 sites/km^2

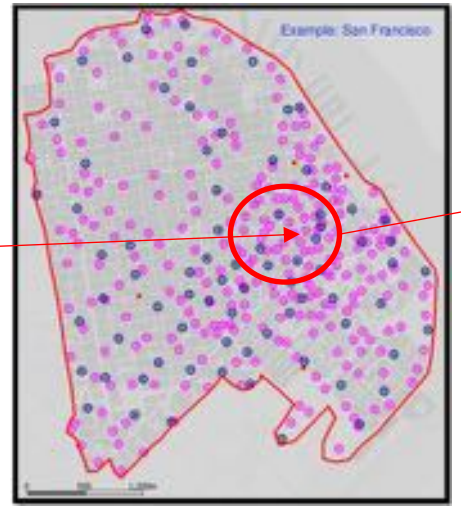
New Architectures (Core and RAN) will be required for Ubiquitous Edge

- 5G deployment introduces new radio infrastructure in dense urban environments
- 5G infrastructure requires multiple aggregation locations (edge data centers) that will need to be deployed in urban settings
- Next Gen applications will require compute, storage and interconnection resources co-located with 5G aggregation

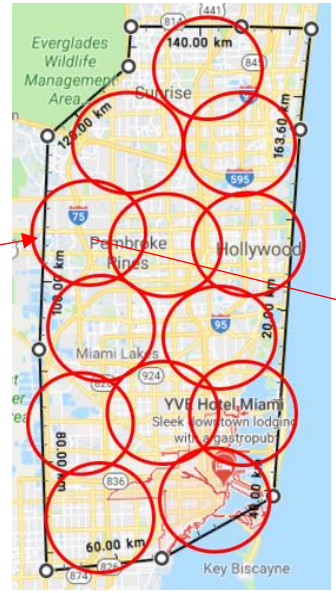


High Frequency Spectrum = high capacity but smaller cells (50 -250 m)

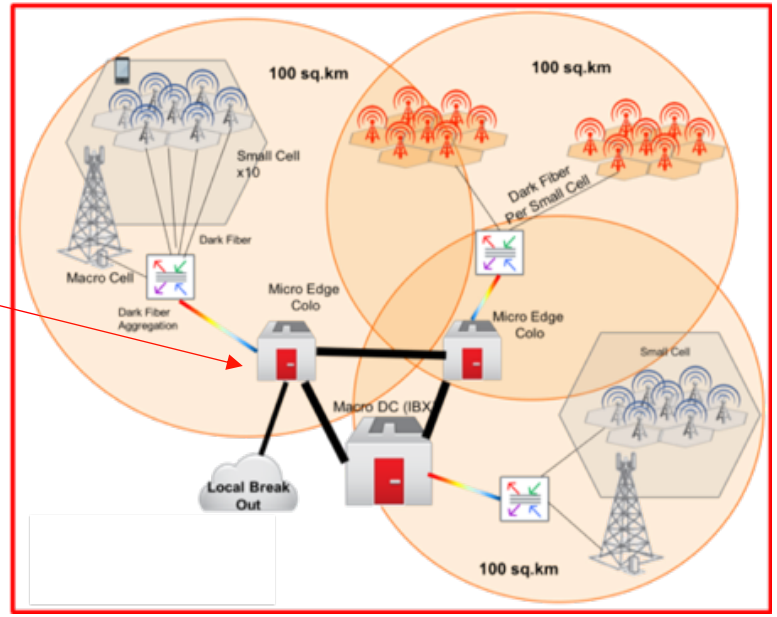
3D beamforming coverage



Thousands of Radio sites per urban metro (~1000 km^2)

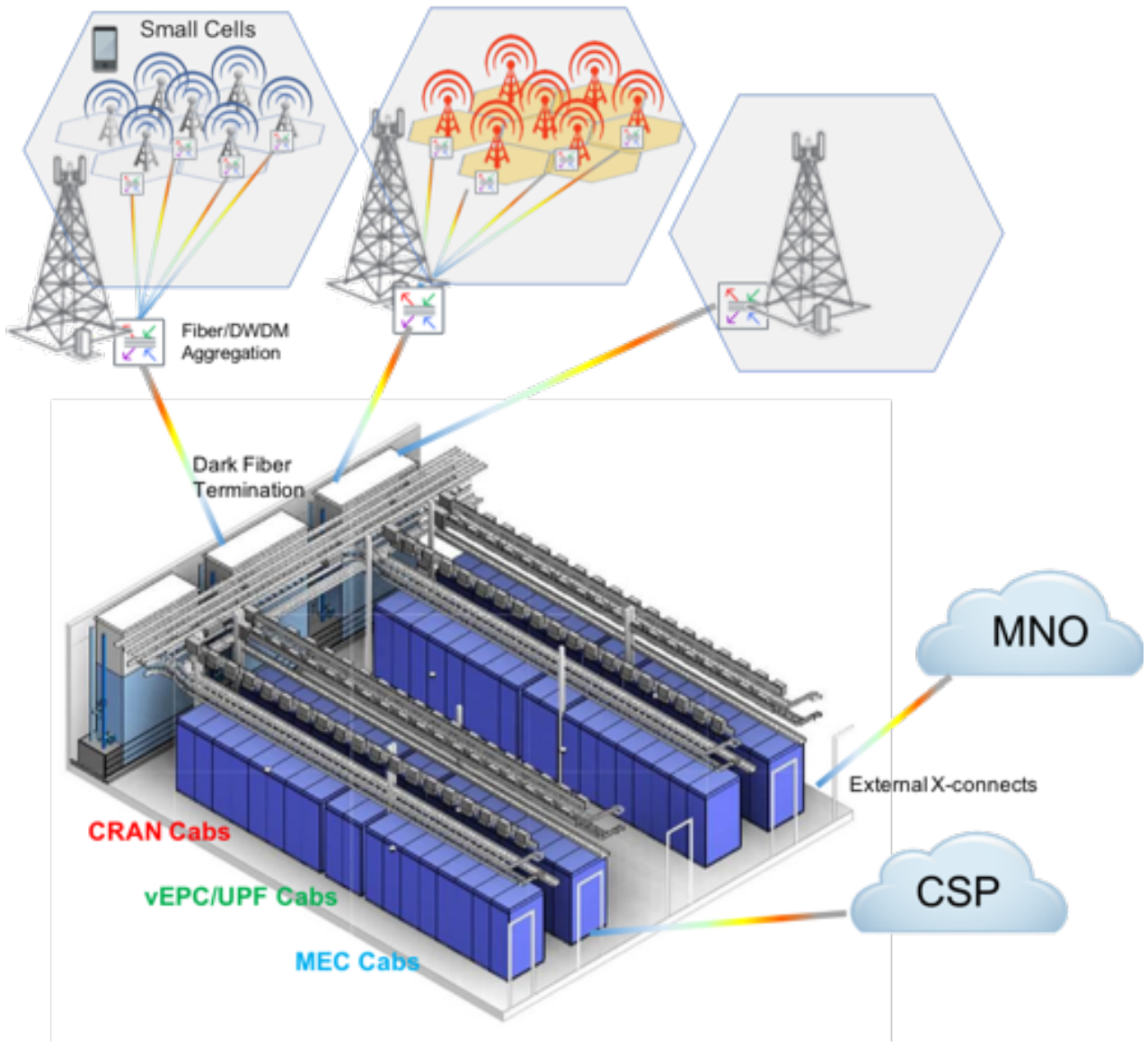


10s of edge aggregation sites per urban metro (~1000 km^2)



Fronthaul/Midhaul Fiber
Micro Edge Data Centers
Packet optical network
Virtualization and Orchestration

Micro Edge Data Center Design Requirements

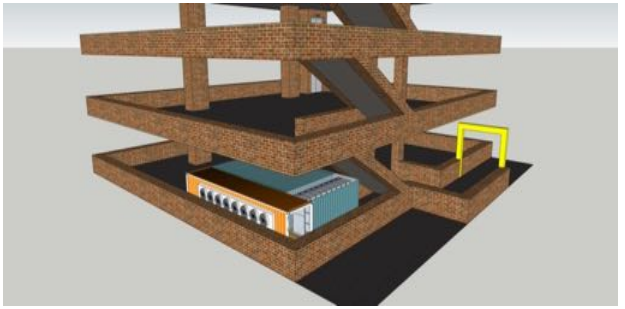


Requirement	Components
System design	Shell, cooling, power delivery
Power to equipment	High efficiency power delivery platform
Resiliency/Availability	Edge sites will be supporting critical telco/wireless infrastructure
Shared infrastructure/Tenancy	Multiple Network Providers Multiple Cloud Providers and Enterprises
Fiber termination	Fronthaul from cell sites Transport for external connectivity
Networking	Optical/DWDM/DF Packet/IP
Security	Access, Surveillance
Monitoring	Unmanned/Centrally / Regionally

Key sustainability and efficiency design principles for urban Micro Edge Data Center

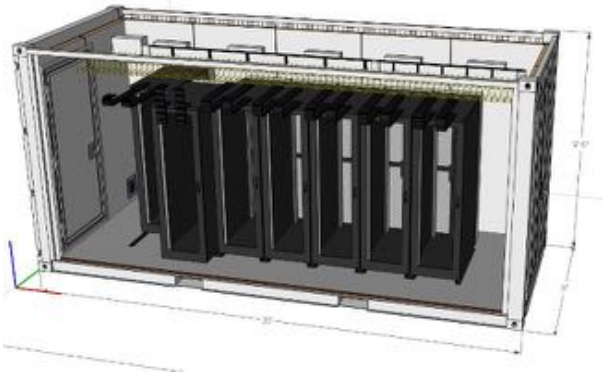
Shared and cost effective
Builds for multiple players

Build and placement
Flexibility



Courtesy: David Hall, Equinix

Efficient systems design



Courtesy: David Hall, Equinix

Environmental and sustainable

New Efficient Bare Metal Cloud Design – Open19

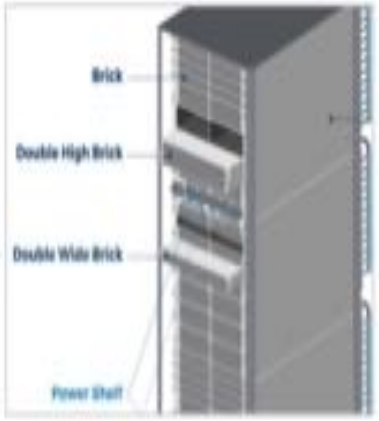
Hardware Platform (Open19 V1)

- "Brick" building blocks
- Basic block is 1U ½ width
- Each brick is allocated 400W power
- Each brick is allocated "QSFP" of network connectivity

Server Brick

- Bricks linearly scale up for more space/power/cooling
  - 1U ½ wide
  - 1U full-width
  - 2U ½ wide
  - 2U full-width

Server Brick Diversity



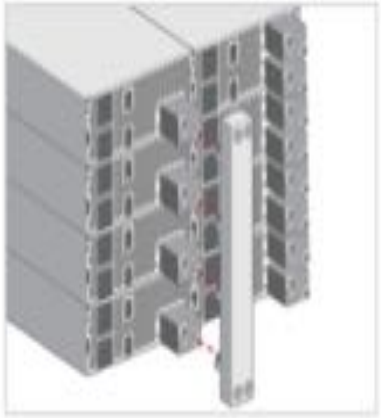
- Assembled into racks for a finished system deployed in the field

High-density Rack
Common DC Power Bus
In-rack Battery Backup

Open19 V2 Changes (Proposed)

- Brick power increases from 400W to 3.6kW maximum
- Each brick is allocated "QSFP-DD" of network connectivity

Server Brick
Higher Power
Faster Network



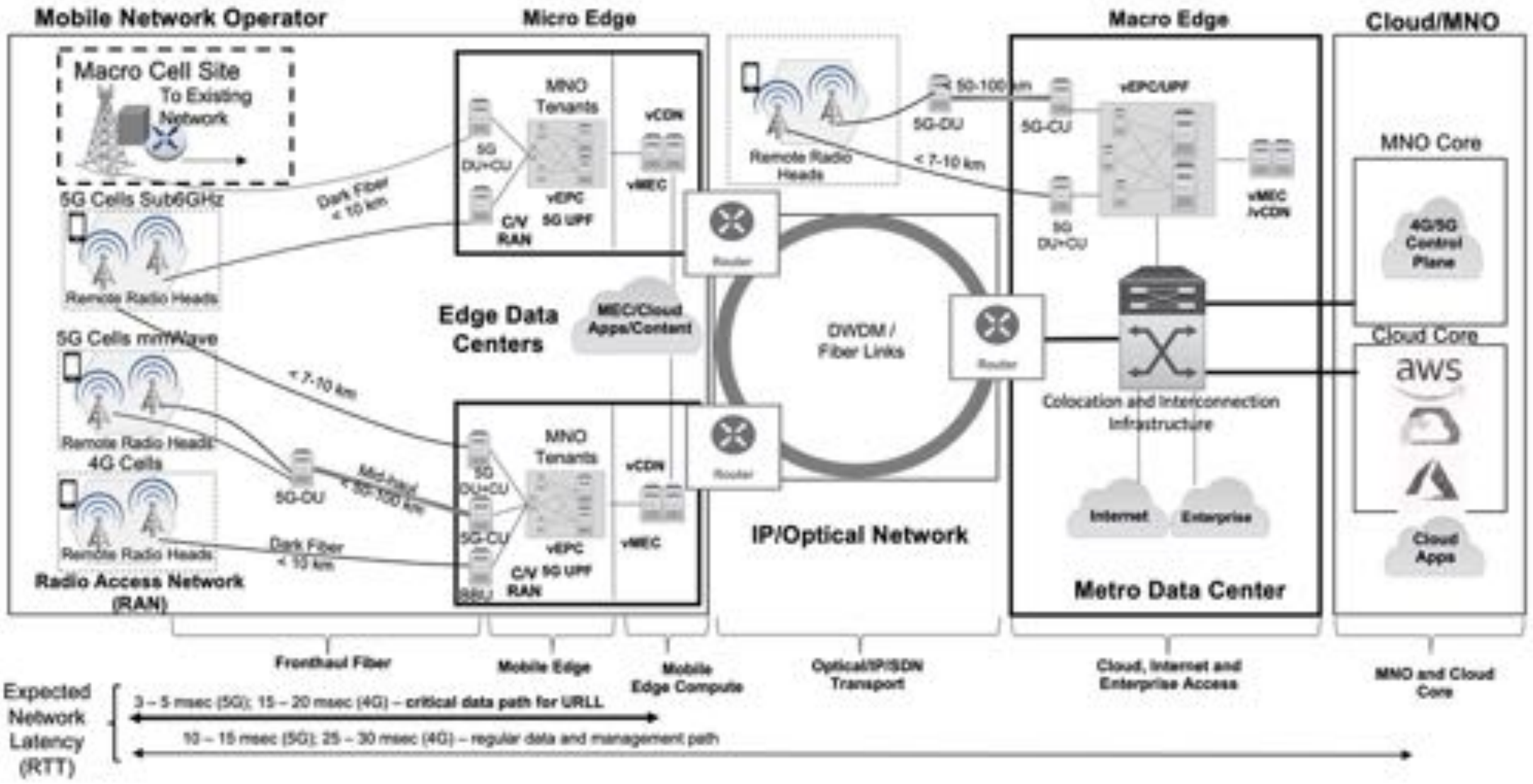
- Single-phase and two-phase direct-to-chip
- Possibly immersion
- Air assist in conjunction with liquid
- Enabled with blind-mate, leak-free connectors and manifolds

Liquid Cooling
Direct to Chip

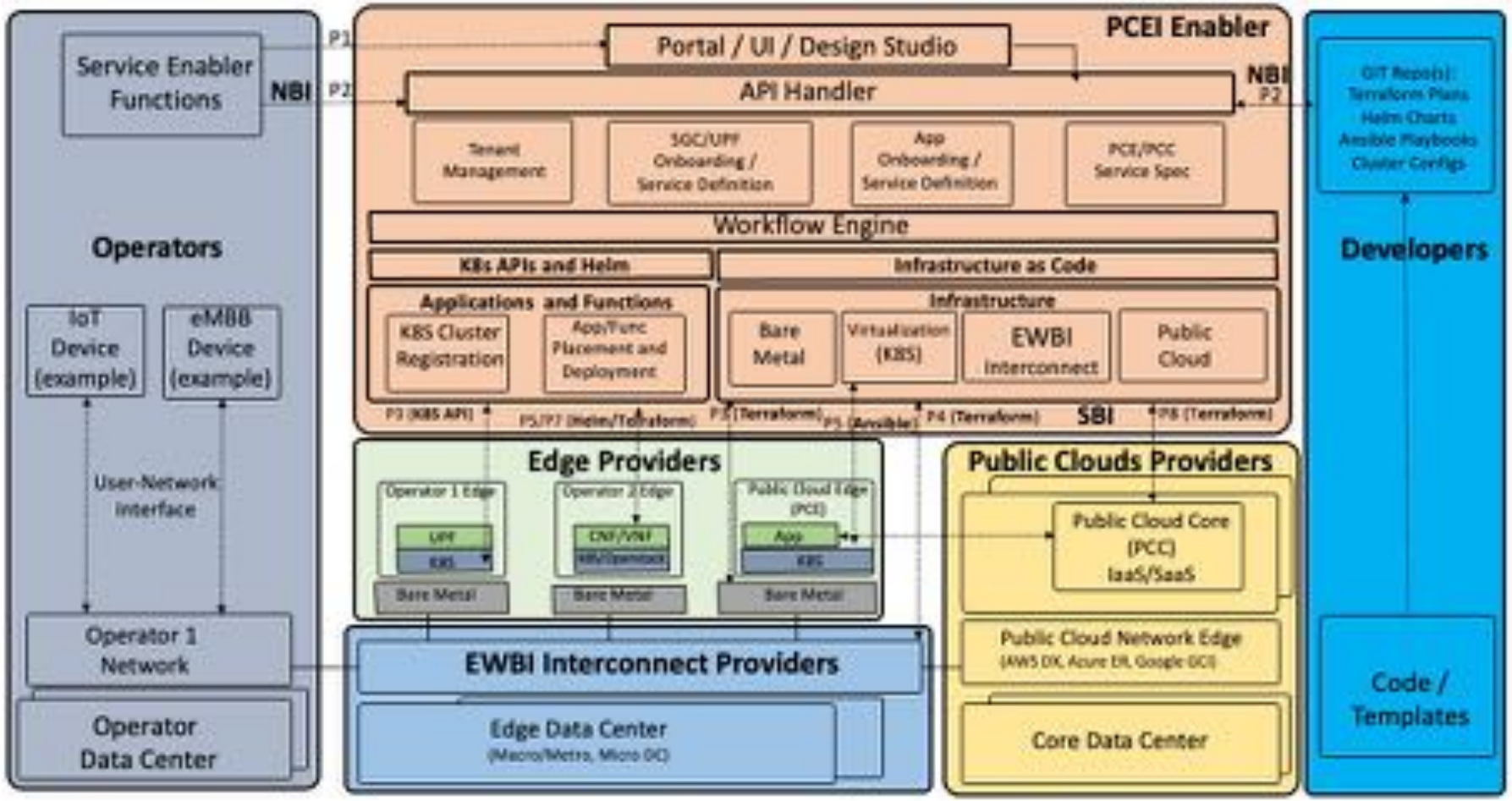
- Power shelf output voltage increases to 48V DC
- Power shelf capacity increases from 9.6kW to 12 kW 1U

Increased Power Density

Ubiquitous Metro Edge Architecture



Facilitating Ubiquitous Edge – Akraino PCEI Release 5(+) Overview



- NBI APIs
  - GIT Integration
  - Dynamic Edge Cluster Registration
  - Dynamic App Helm Chart Onboarding
  - Automatic creation of Service Instance in EMCO and deployment of Apps
  - Automatic Terraform Plan Execution
- Workflow Engine
  - Camunda
- Integrated Terraform Plan Executor
  - Azure (PCC)
  - AWS (PCC)
  - Equinix Fabric (Interconnect)
  - Equinix Metal (Bare Metal Cloud)
  - Openstack (3PE)
- Equinix Fabric Interconnect
- Multi-Public Cloud Core (PCC) Orchestration
- Kubernetes Edge
- Openstack Edge
- Cloud Native 5G UPF Deployment

Who Is Equinix

Equal access, neutrality and interconnection

DESTINATION STRENGTH FORTRESS PERSPECTIVE CONNECTION

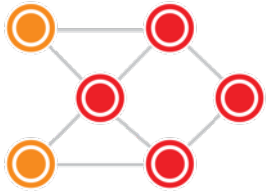
History of Equinix

At the center of digital transformation for over 20 years

Networks

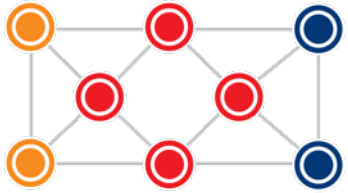
INTERNET

E-commerce and content



WEB

Exchanges



ELECTRONIC TRADING

Clouds

CLOUD

Enterprises

DIGITAL ECOSYSTEMS

Equinix Data Centers

Micro Edge DC

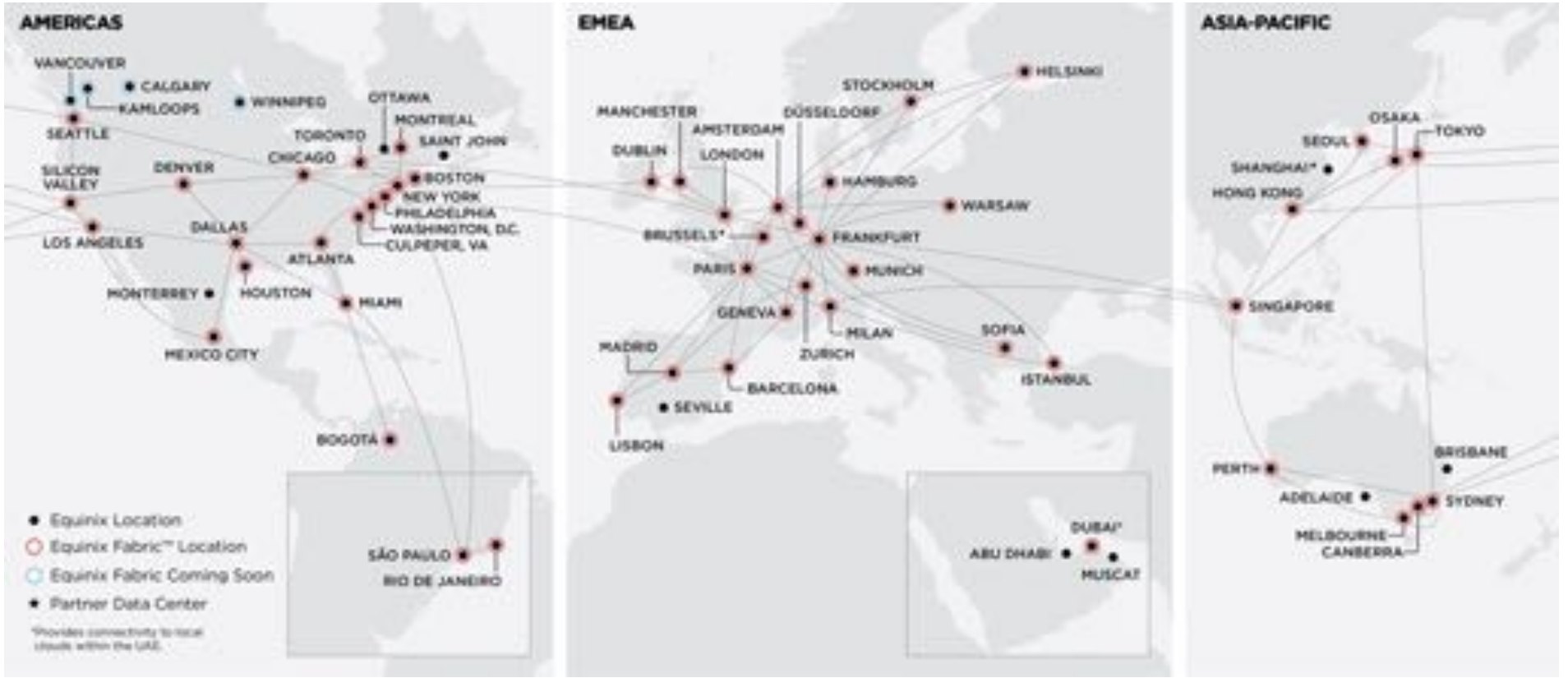
Macro Edge DC

Equinix by the Numbers

Global infrastructure and exchange platform for digital business

240	66	27	5	10,000+	419,000+	99.9999%
Data Centers	Metros	Countries	Continents	Companies	Interconnections	IBX Uptime

IBX: International Business Exchange (DC)

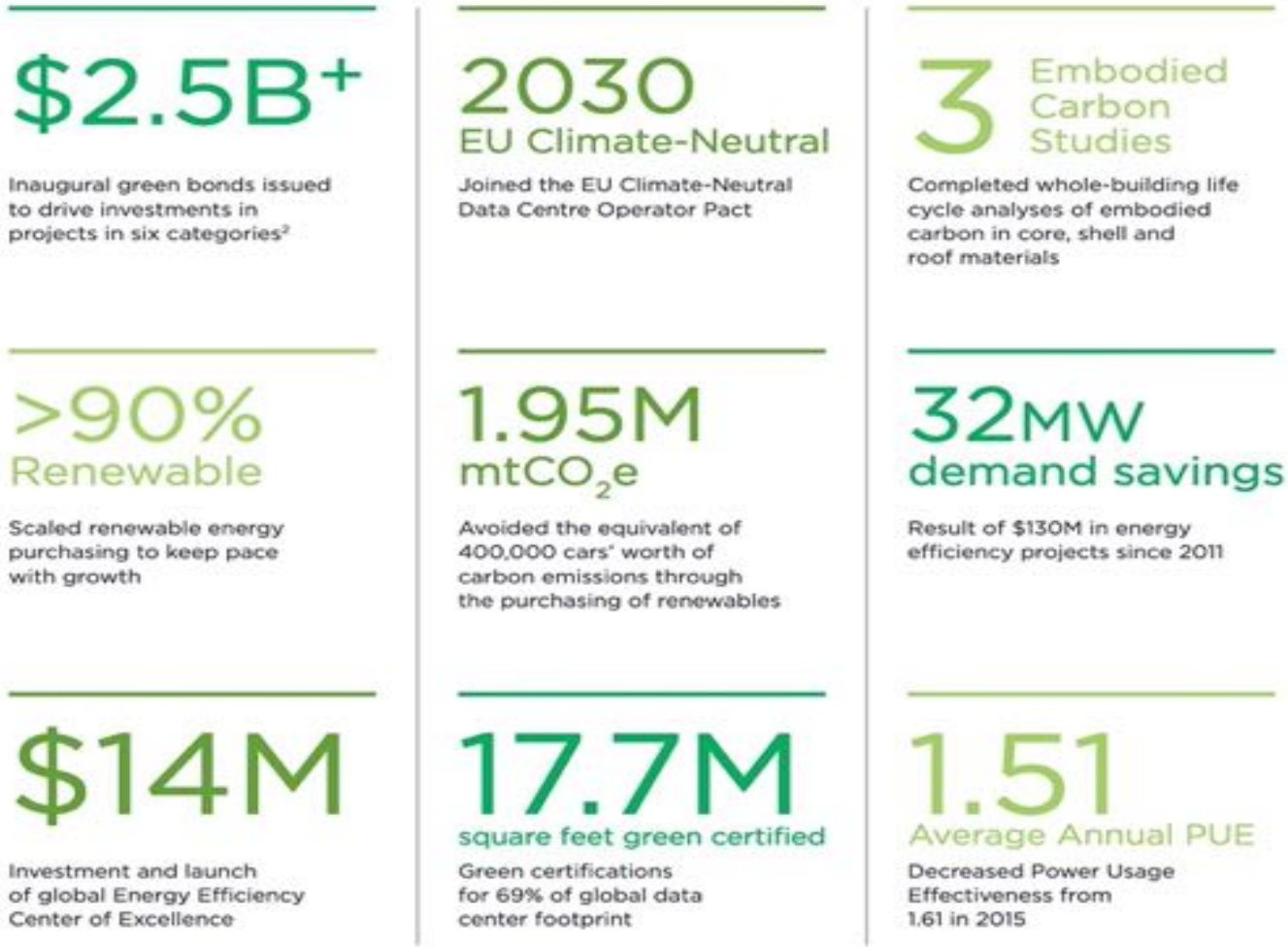


- 2,000+ Networks
- 650+ Media & Entertainment
- 1,250+ Financial Services
- 3,000+ Cloud & IT
- 3,000+ Enterprises (50%+ of Fortune 500)

- Network Edge (NFV)
- Bare Metal (BMaaS)

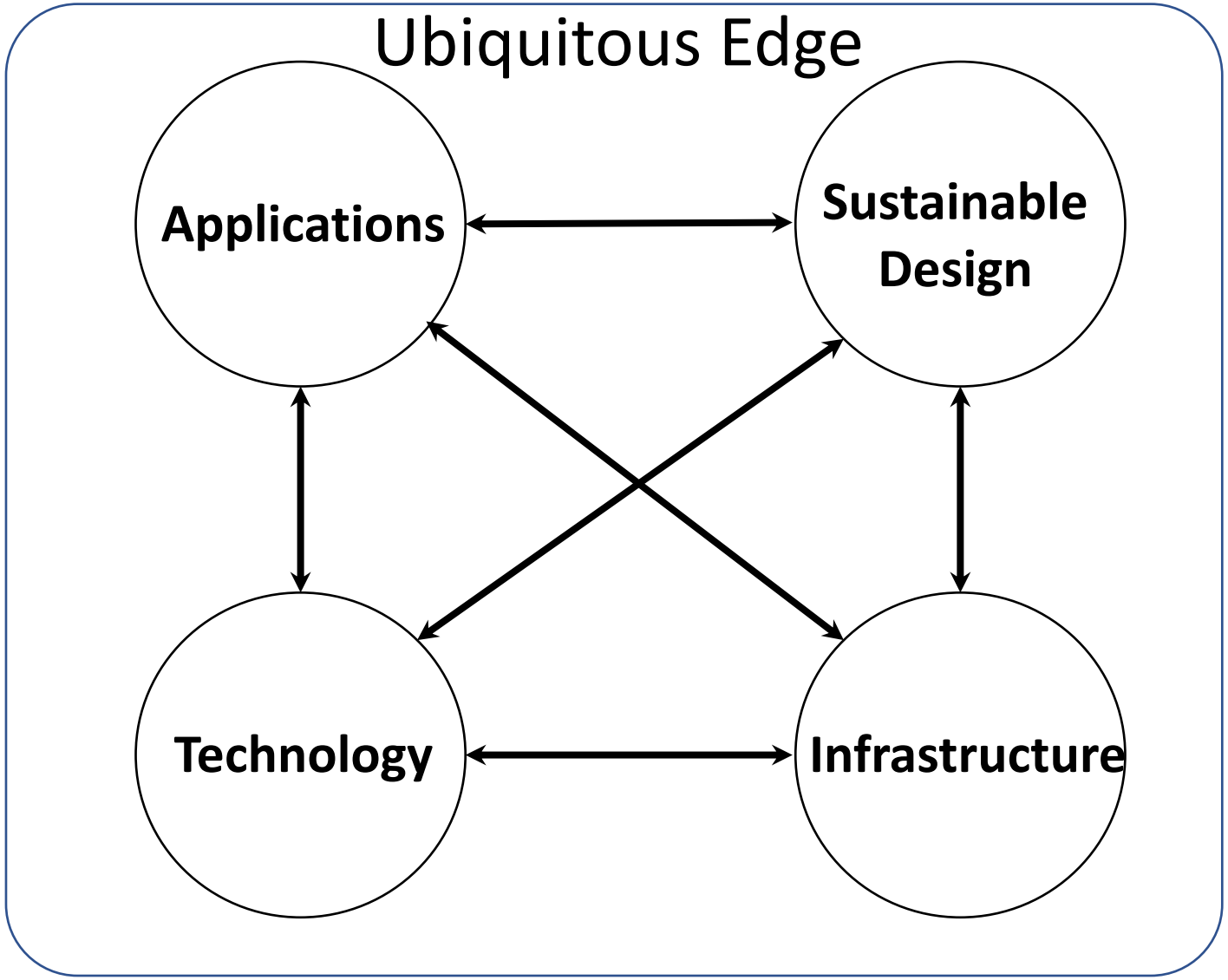
- Equinix Fabric (SDN-enabled)
- Internet Exchange (12.6+ Tbps)

Equinix Sustainability Report



https://sustainability.equinix.com/wp-content/uploads/2021/05/Sustainability-Report-Highlights-FY2020.pdf

Inter-related grid of requirements and benefits



Conclusions

- Population distribution/density/clustering and next generation edge and communications infrastructure clustering are directly related

- Infrastructure that supports ubiquitous edge and networks (5G and beyond) must be an integral part of a sustainable design

- Applications making use of the integrated infrastructure will further enhance the utility of that infrastructure to the users by enabling higher levels of information awareness, coordinated processing and efficiency in delivering services ranging from critical to helpful to entertaining