5G Interconnected Ecosystems for the Development of Smart Cities

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Agenda

- Strategy and Governance
- Smart Cities: Connected Ecosystem of Ecosystems
- 5G Categories
- Smart Cities Roadmap Development

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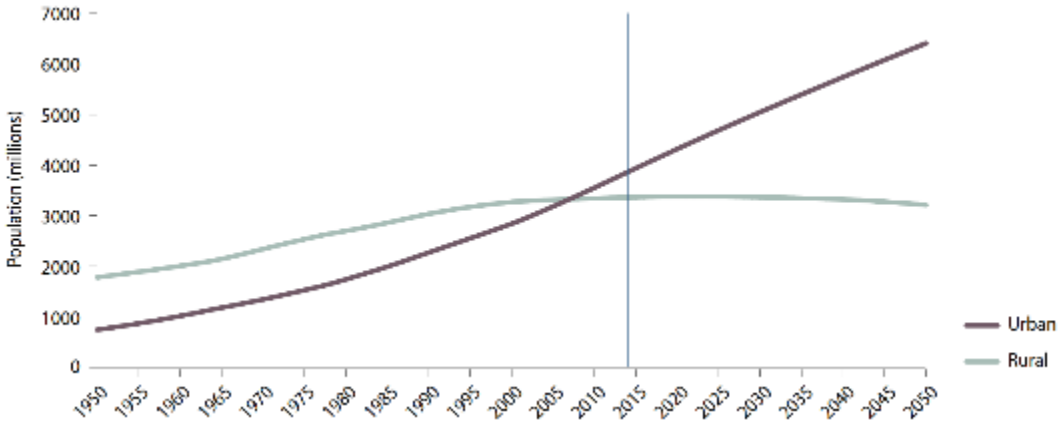
Applications and Services

Strategy and Governance

Motivation

- Cities produce 80% of the world's carbon emissions. Natural resources are exploited and wasted in cities, e.g. 50% of water resources are wasted due to leaky infrastructures, and residential and commercial buildings consume 1/3 of the global energy produced.
- There are more urban residents than rural residents across the globe. Global urban population increases by 2 people every second !
- Cities strive towards economic development, improve quality of life, and attract and retain residents, businesses, and visitors.
- Venture capital investment tends to be highly concentrated in center cities and are influenced by innovation, access to talent, high tech industry clusters, density, wages and income, and openness and diversity.



Global mobile industry GDP contribution
2017 - $3.6 trn (4.5%)
2022 - $4.6 trn (5.0%)

Source: The Mobile Economy 2018, GSMA Intelligence

Urban Population increases by 2 people ever second!

Natural resources are strained

Cities compete with each other to attract and retain residents, businesses, and visitors

4 Source: "World Urbanization Prospects: The 2014 Revision," United Nations, 2014 [Online]. Available: https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf

Smart Cities Strategy Development

Alignment within ecosystems - each activity is consistent with the overall strategy, e.g. connecting people, places and things in ecosystem(s)

Alignment among ecosystems – connected ecosystems complement each other, e.g. coordinated public safety, health care, transportation ecosystems

Optimization of ecosystems – "smart" coordination & information exchanges across ecosystems that are geared towards economic development, quality of life, and attraction & retention of residents, businesses, and visitors.

Smart City strategy should combine activities that fit and reinforce each other.

Strategic fit is difficult as it requires integration of decisions & actions across different ecosystems

- Ecosystem structures, systems, & processes need to be aligned with overall strategy
- Governance activities needs to address strategic goals, culture, trust, resources, technologies, policies, and a diverse stakeholder mix

Smart City Ecosystem Governance

Orchestrator Model

Smart City Integrator Model

Extended Enterprise:
- City has centralized control and coordination of required activities, qualified service delivery suppliers, and project implementation.

Vertical & Lateral Structure:
- Supports an integrated service with a focus on client needs

Advantages:
- Quality Control. Reduced risk of market failure

Disadvantages:
- Requires capability, capital, and human resources

Smart City Platform Model

Market Based Platform:
- City facilitates the exchange of ideas, stakeholder interactions, market drivers, and information processes.
- Open data platforms enable ecosystem provider interaction.
- **Trust is essential. Data security & privacy are critical for the development of smart cities**

Horizontal & Networked Structure:
- Multiple disintegrated services that focus on client and service provider needs

Advantages:
- Different approaches and solutions that could scale as well as increase the level of services and features.

Disadvantages:
- Need for early investments with no city based quality control enforcement methods. Services are also subject to market conditions

Orchestrator Model: dynamically adjust between Integrator or Platform to evolve
Ecosystem of Ecosystems Structure: Multiple complex connected ecosystems with multiple stakeholders and technologies.

Source: Governing the City: Unleashing Value from the Business Ecosystem,
Ivanka Visnjic, Andy Neely, Carmelo Cennamo, and Nikola Visnjic, California Management Review, 2016, Vol. 59(1) 109–140

Connected Ecosystems of Ecosystems

- **Smart Cities Ecosystem of Ecosystems**
  - Quality of Life and Economic Growth: attract and retain Commercial, Business, Entertainment, & Residential interests
  - Technologies: Analytics to support congestion relief (e.g. parking apps), increase tourism (e.g. AR/VR), and stimulate economic activity
  - **Cross-Ecosystem Interactions: Governance of ecosystem structure to coordinate complex interacting ecosystems.**
- **Connected Vehicles Ecosystem**
  - Transportation Modes: Roads, Rails, Waterways, Air Travel, Pedestrians, Bicycles
  - Technologies: DSRC, V2X, CBTC, PTC
  - **Cross-Ecosystem Interactions: EV charging and electrical grid loading, public safety**
- **Connected Health Ecosystem**
  - Continuum of Care: trauma centers, hospitals, EMS, outpatient monitoring
  - Technologies: Health IT, EHR, Broadband Communications, MBANs
  - **Cross-Ecosystem Interactions: EMS / Connected Vehicles, Analytics to track outbreaks, citywide continuum of care, etc**
- **Utilities Ecosystems**
  - Broad range of utility services: Smart Grids / Electricity, Waste Management / Sanitation, Water, Gas
  - Technologies: Meshed networks, narrowband RF, LPWA, AMI
  - **Cross-Ecosystem Interactions: energy conservation, spot pricing for utility market, energy efficiency & cost reduction for smart buildings,**
- **Public Safety Ecosystem**
  - Safety and Governance: First Responder / Public Safety, Municipal Services / Public Works, and Environment applications
  - Technologies: 5G, LMR, WLAN, satellite communications for fleet management, emergency response
  - **Cross-Ecosystem Interactions: connected vehicles, priority and preemption for first responders, etc**
- **Agricultural Ecosystem**
  - Information and monitoring services, food supply chain visibility, mobile financial services,
  - Technologies: 5G, LPWA, WLAN (inc TV white spaces), satellite communications
  - **Cross-Ecosystem Interactions: food supply chain visibility inc urban food desert reduction, massive IoT, connected vehicles, public safety,**

Smart City development should address pain points and address goals & aspirations while retaining the unique culture of each city.

Solutions should be aligned with the underlying strategy and complement each other.

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Applications and Services

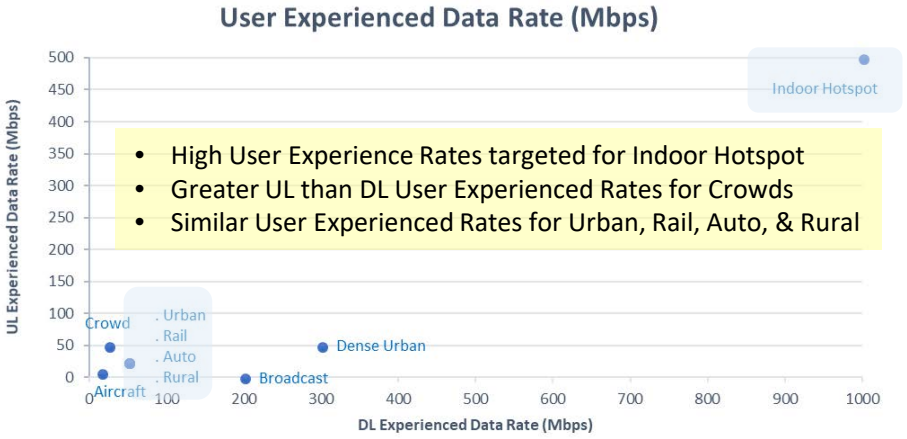
5G Categories & Smart Cities Roadmap

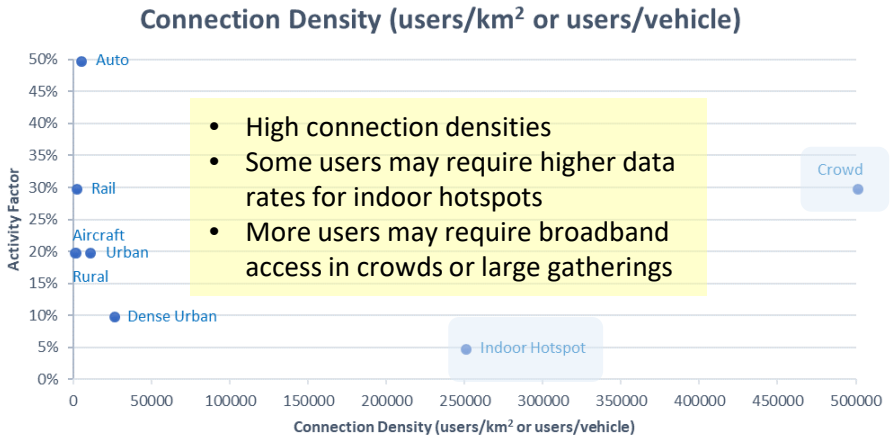
Smart City Applications – 5G Network Operations

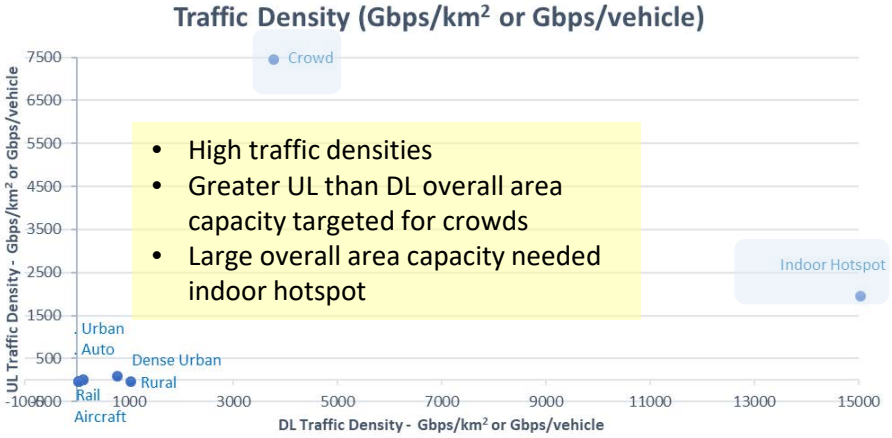
Network Slicing	Ability to create dedicated logical networks within a shared infrastructure
Multiple Access Technologies	Support for 3GPP and non-3GPP network connectivity with potential simultaneous services.
Network capability exposure	Extend network capabilities to 3rd party providers e.g., APIs, QoS policy, dynamically customization of dedicated network slices that support diverse use cases.
Flexible broadcast/multicast service	Supports multicast/broadcast network design, live adhoc broadcasts that may not have been stored on a video server, and simultaneous user access to unicast data and broadcast service.
Markets requiring minimal service	Adaptability for difficult environments (e.g., remote areas,) with local operations constraints (availability and reliability of local interdependencies, e.g. power). Support for minimal user experience, e.g. 100kbps with 50ms latency, while prioritizing emergency services.
Extreme long range coverage in low density areas	Long range coverage (up to 100 km) in low density areas (up to 2 user/km^2), a minimum user throughput of 1 Mbps DL and 100 kbps UL.
Multi-network connectivity and service delivery across operators	Service providers may enable users to access multiple networks simultaneously.

Source: 3GPP

Enhanced Mobile Broadband (eMBB) Considerations







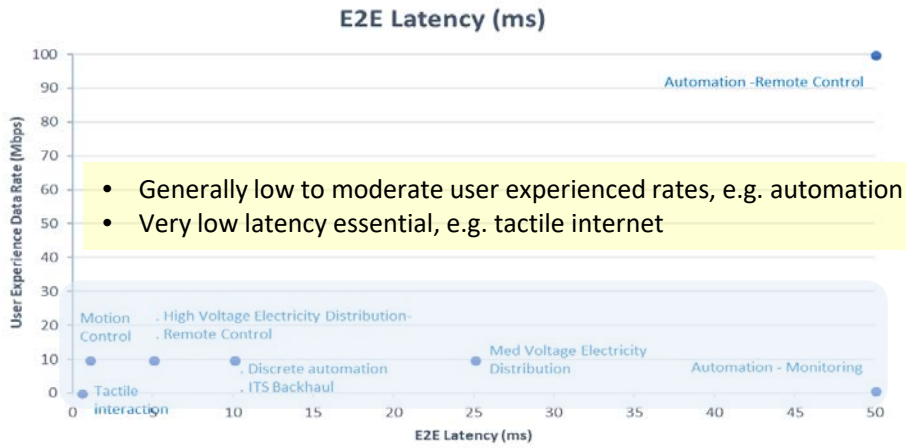
5G Drivers: High data rate, low latency, traffic density, connection density, varying levels of mobility

5G Deployments: Indoor/Outdoor Local and Wide Area Connectivity

Fixed Mobile Convergence: combined use of fixed broadband access, e.g. fiber, and 5G access network.

Femtocell Deployment: seamless user experience over radio access and Femtocell access using fixed broadband networks.

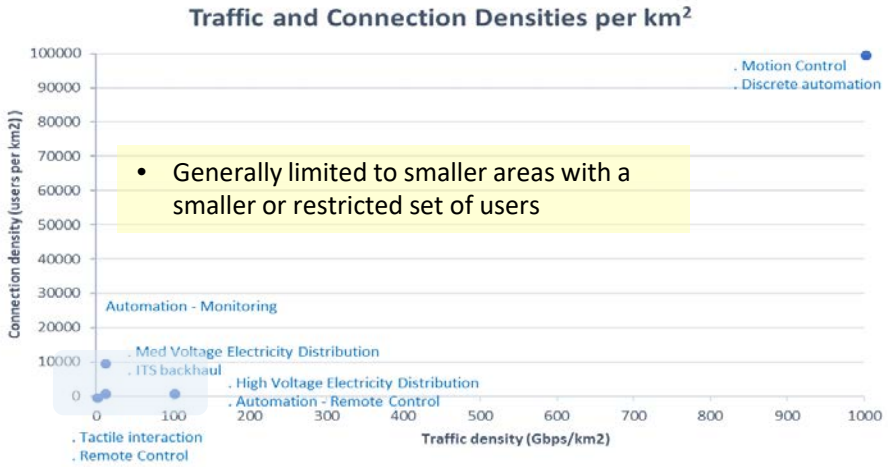
Critical Communications Considerations



- Generally low to moderate user experienced rates, e.g. automation
- Very low latency essential, e.g. tactile internet

Other Considerations

- Availability, e.g. deployables
- Reliability, e.g. industrial control, drone connectivity
- Positioning Accuracy, e.g. connected vehicles



- Generally limited to smaller areas with a smaller or restricted set of users

5G Drivers: Low latency, reliability, traffic density, position accuracy

Mission Critical Services: critical communications that may require a higher communications priority, e.g. first responders, disasters.

Smart City Applications – Massive IoT & eV2X

Massive Internet of Things (MIoT)	**5G Drivers**: Communications efficiency, traffic density, communications density, position accuracy
	Operational: network servers/applications and devices support to identify and reach each other, IoT security
	Connectivity: Direct 3GPP connection (e.g., a sensors), indirect 3GPP connection (e.g., a smart wearable communicating via a smart phone), direct device connection (e.g., a biometric devices that communicate directly with other biometric devices.
	Resource Efficiency: include bulk provisioning, resource efficient access, optimization for device originated data transfer, and mobility management efficiencies for stationary or limited mobility devices.
eV2X	**5G Drivers:** High data rate, low latency, reliability, traffic density, connection density, varying levels of mobility, high position accuracy
	Vehicles Platooning: All the vehicles (may be autonomous) in the platoon receive periodic data from the leading vehicle.
	Advanced Driving: enables semi-automated or fully-automated driving. Vehicles and/or RSU shares data obtained from its local sensors with vehicles in proximity,.
	Extended Sensors: enables data exchanges from local sensors or live video data among vehicles, RSUs, devices of pedestrians and V2X application servers.
	Remote Driving: enables a remote driver or a V2X application to operate a remote vehicle

Source: 3GPP

Smart City Deployment Considerations

Implementation Drivers

High data rates **(User Experienced Data Rate**: the minimum data rate required to achieve a sufficient quality experience)
Low latencies
Reliability
Resiliency
Traffic density (e.g. traffic within certain area of interest)
Connection density (e.g. number of connections within a certain area)
Speed / Mobility
Accuracy of position determination

Smart Cities Roadmap Considerations

Ecosystem	Introductory Stage	Growth Stage	Maturity Stage	Decline Stage
Smart Cities **Complex interdependent ecosystem coordination with a diverse set of stakeholders working with a disparate set of technologies evolving at different rates.**	Experimentation with fragmented solutions	Alignment of solutions. Early best practices emerge. Specialized and low cost solutions will emerge that is positioned for the needs of different city segments. Urban planners begin to incorporate more technologies that transparently blends into the inner fabric of the city.	Successful actors emerge. Industry structure and market positioning becomes critical. Tangential sectors that may include combinations of various ecosystems. The efficiency and effectiveness of a complete smart city deployment is dependent on the ability for connected people, places, and things.	Seamless interoperable connected ecosystem of ecosystems with a smaller set of successful actors. Smart Cities evolve to the next generation
Core Component Ecosystems with varying rates of Industry Structure Life Cycle Stages				
Communications Ecosystem: Broadband Communications, e .g. Terrestrial 3GPP and non-3GPP mobile, Satellite, Fixed Broadband				
Connected Vehicles: Transportation Modes, e.g. Roads, Rails, Air, Waterways, Pedestrian				
Connected Health: Continuum of Care, e.g. trauma centers, community hospital, clinics, emergency transport, outpatient services				
Public Safety: First Responders, e.g. Police, Fire, EMS, and situational awareness for overall safety and security				
Utilities and City Services: Electricity, Gas, Water, Sanitation, Public Works				
Agriculture: Information and monitoring services, food supply chain visibility, mobile financial services				

Conclusion

- Smart Cities is a Connected Ecosystem of Ecosystems
- Each city may have different approaches for economic development, quality of life, attraction & retention of residents, businesses and visitors
- Address trust, privacy and security concerns related to the open data model, e.g. personal information.
- Smart city governance: orchestrator, integrator and platform models
- Technologies will need to be interoperable
  - *within* each vertical (e.g. intermodal transportation coordination between connected vehicles and railroad crossings) and
  - *across* major verticals (e.g. electric vehicle charging and impact to smart grid).
- Technology should operate seamlessly in the background to connect people, places, and things

Smart Cities presents both opportunities and challenges to address sustainability, resource conservation, economic and technology development initiatives.

The evolution to smart cities may create competition to attract and retain key stakeholders through a connected ecosystem of ecosystems.

Smart City is a connected ecosystem of ecosystems that spans diverse technologies, governance approaches, privacy, and security, and other stakeholder considerations that include economic growth and quality of life.

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Q&A

IEEE 5G Technology Roadmap Working Group

https://5g.ieee.org/roadmap