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Emerging Technology

IES San Francisco Section

January 21, 2015

Lighting and the

Internet of Things

What Things?

People
- Cell phones and watches
- Jewelry and clothing
- Toys and tools

Homes
- Garage doors and front doors
- Thermostats & smoke detectors
- Security cameras
- Electricity, gas, and water meters
- Solar panels and hot water heaters
- TVs and entertainment systems
- Kitchen and laundry appliances
- Toilets, sinks, and faucets
- Of course, computers, pads, etc.

Cities
- Street lighting
- Parking meters and spaces
- Traffic & pedestrian signals
- Irrigation
- Security systems

Vehicles
- Cars, trucks, and other vehicles
- Trains, planes, ships

Shipping
- Shipping packages and containers
- Rail and shipyards
- Warehouses

Factories
- Loading docks
- Manufacturing equipment
- Raw materials, WIP & finished goods
- Security, fire suppression

Agriculture
- Fields & farm animals
- Haystacks and holding ponds

Environment
- Wells, rivers, lakes and oceans
- Tree tops and mountain tops
- Manure piles and land fills

Utilities
- Grid, meters, pipes, valves,…

In other words, pretty much Everything!

Thesis: "If you give a mouse a cookie…"

- If you're putting in LEDs, you should control it with a network.

- If you have a network, you should consider using it for other applications.

- If you build an IoT, you need to understand your needs and concerns.

- Then, you need to select the right technology.

- During the entire process, you should talk with vendors and users who are doing it.

Agenda

Smart Lighting to Smart Place (1)

Benefits & Concerns (2)

Technologies (3)

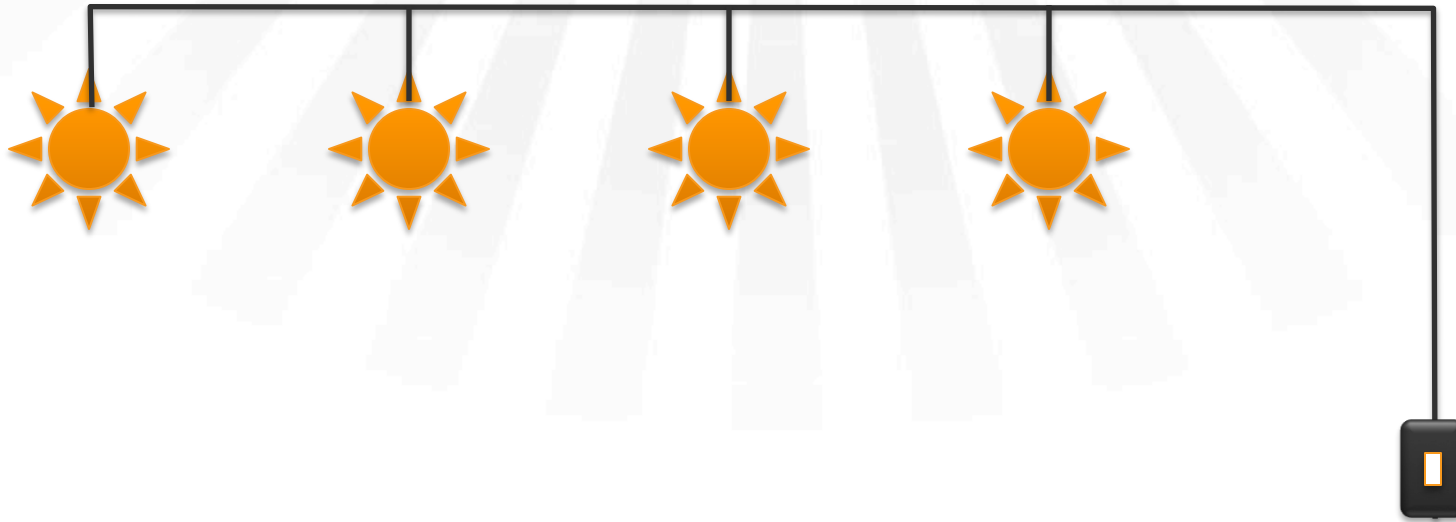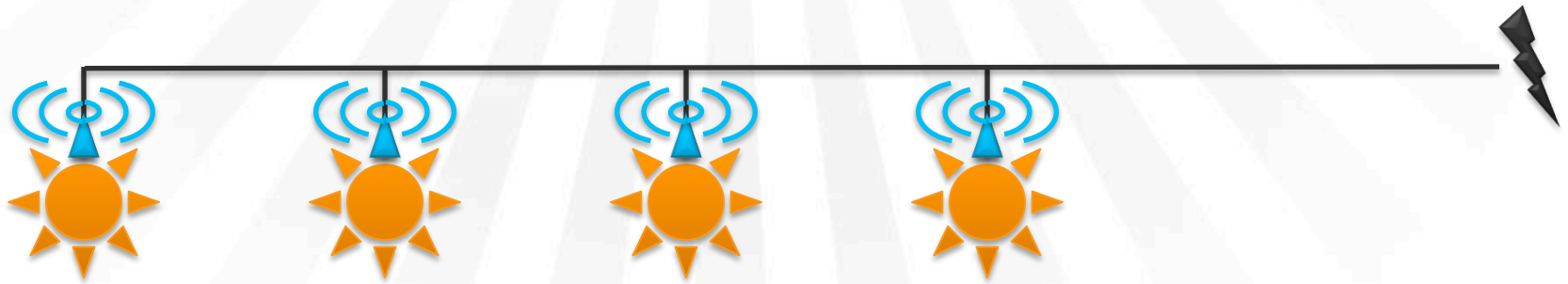**Step by Step from Lighting to the Internet of Things**

1 Making Smarter Places

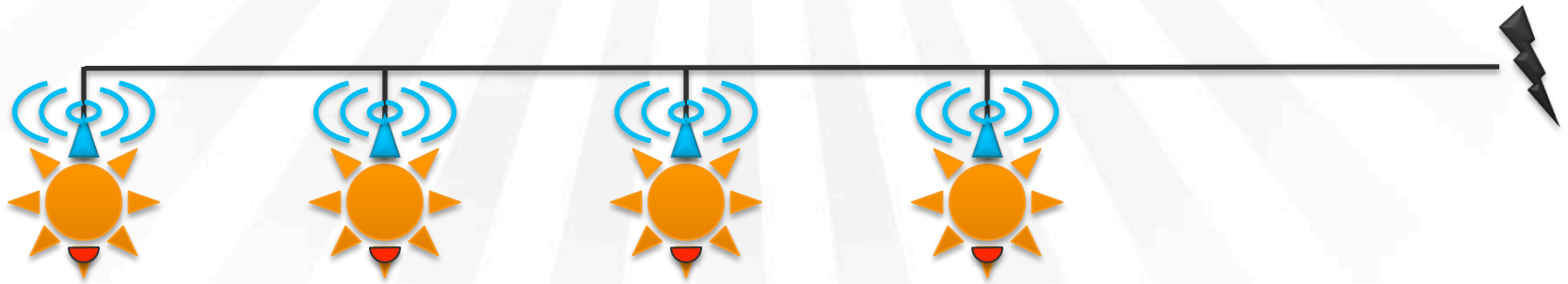**Thinking outside the fixture.**

Stupid Lighting Architecture

Smarter Lighting Architecture

Switch can be energy harvesting (EnOcean?)
Wireless control for on/off/dimming adds flexibility
Special switch can add CCT controls.
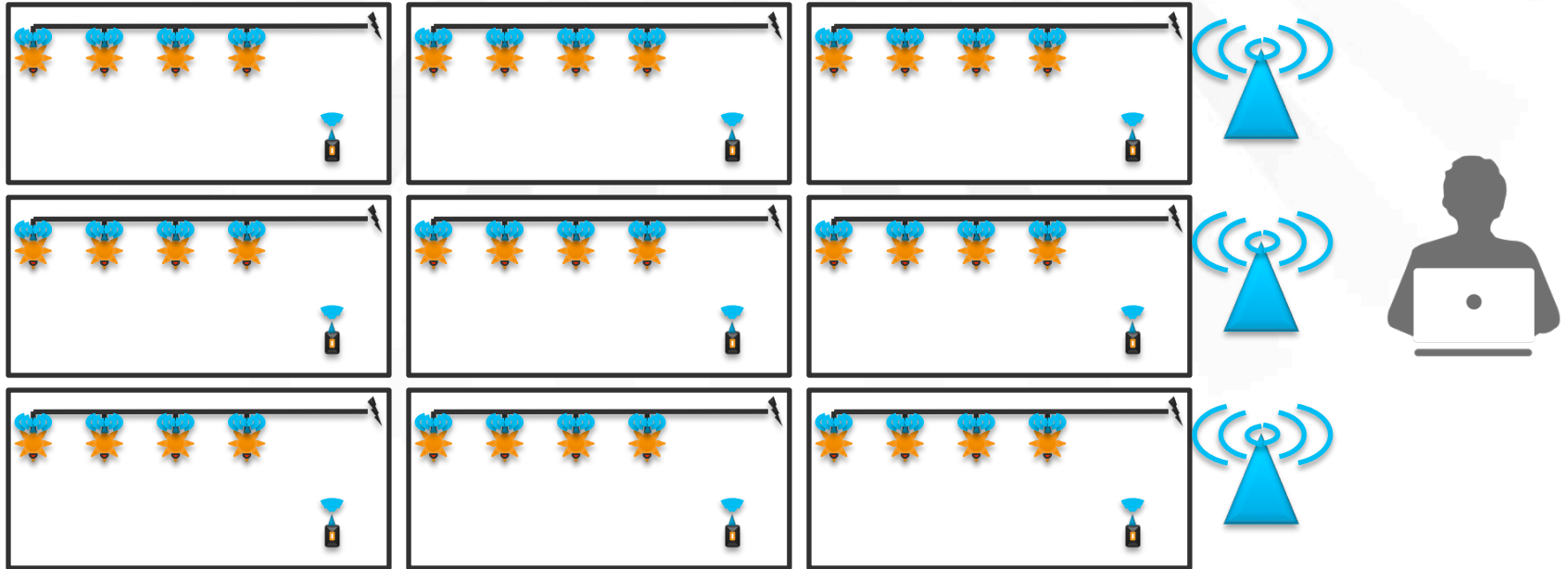
Even Smarter Lighting Architecture

Add a little more brains + memory to the lighting controller.
Lighting controller stores its "state" and programming.
Add per-fixture(?) occupancy and ambient light sensing.
Let the lights talk to each other
         ("I see someone – you should turn on")

But how do you program these lights? …

Office Building Lighting Architecture

Single workstation (/server) controls and manages all lights in the building.
Lights are programmed to respond to time-of-day, day of week, ambient & occupancy.
Lights are constantly sending real-time data on occupancy and light level.
What can we do with this data?...

Lighting In Its Local Context

REGION — CITY — CAMPUS — BUILDING

LIGHTING · Production · IT · People · Utilities · Safety & Security
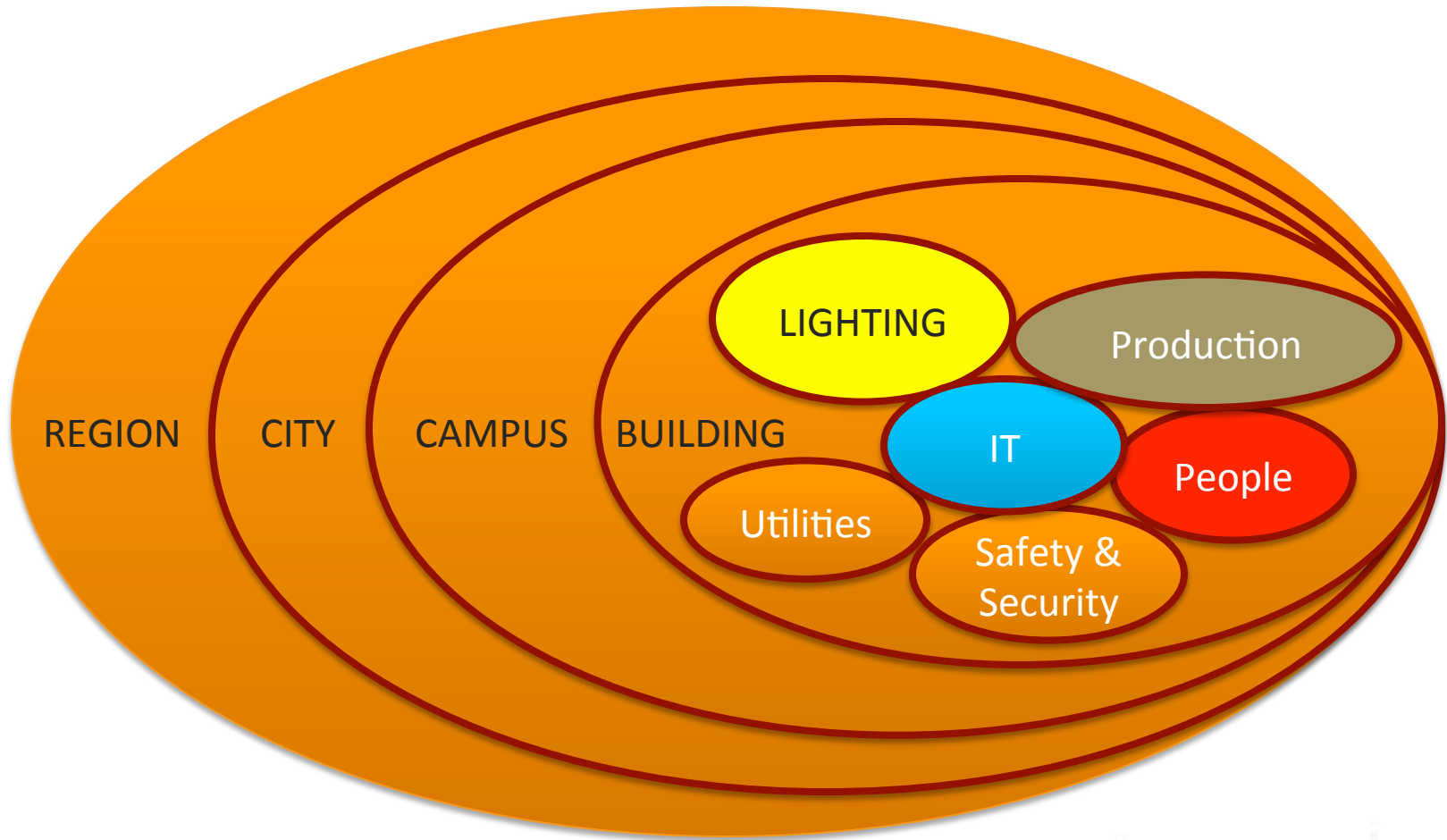
Building IoT Architecture
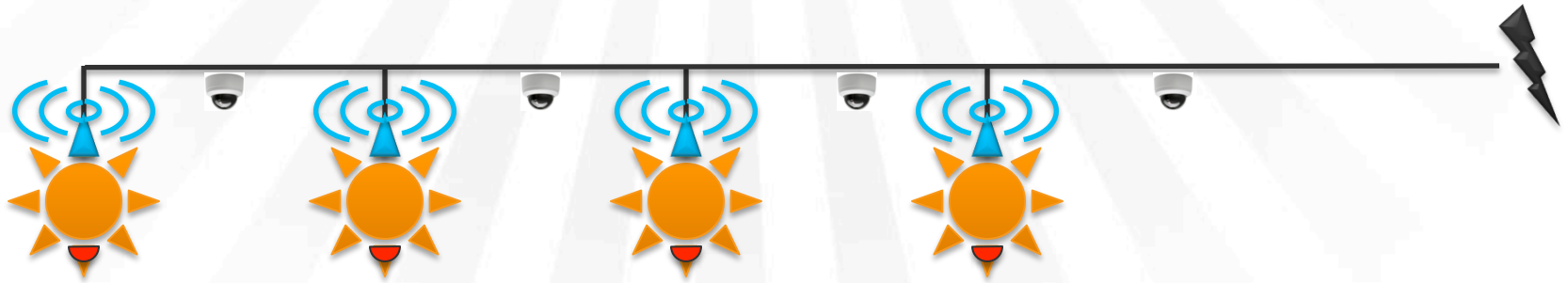
Add temperature sensing.
Add audio sensing (sound level = occupancy, security)
Connect backbone to thermostat and HVAC system
Connect to sky lighting and window blinds
Connect to Safety and Security systems
Send ALL of the data back to the server!

(Lighting) Network becomes the Backbone of the BMS

Beyond the Building: Smart Campus

LIGHTING
- Signage
- Driveways
- Parking
- Paths
- Wallpack
- Floods
- Loading
- Courtyards

BUT ALSO:
- Gates
- Cameras
- Alarms
- Irrigation
- Solar?

Use Case – Smart Campus Parking

- User drives into lot.
- Network recognizes user smart phone or even car/license.
- Lighting brightens along path of vehicle to empty space
- Network remembers where user is parked, then illuminates path to door.
- Lighting-based video/audio network watches lot for unusual activity, such as loitering, cries for help, crashes, etc. and alerts Security if necessary.
- User leaves building. Lighting blinks over car and illuminates walking path to car, perhaps also shows location in Maps app on smart phone.
- Video cameras monitor user from building to car for safety

Property Mgmt Co. Perspective
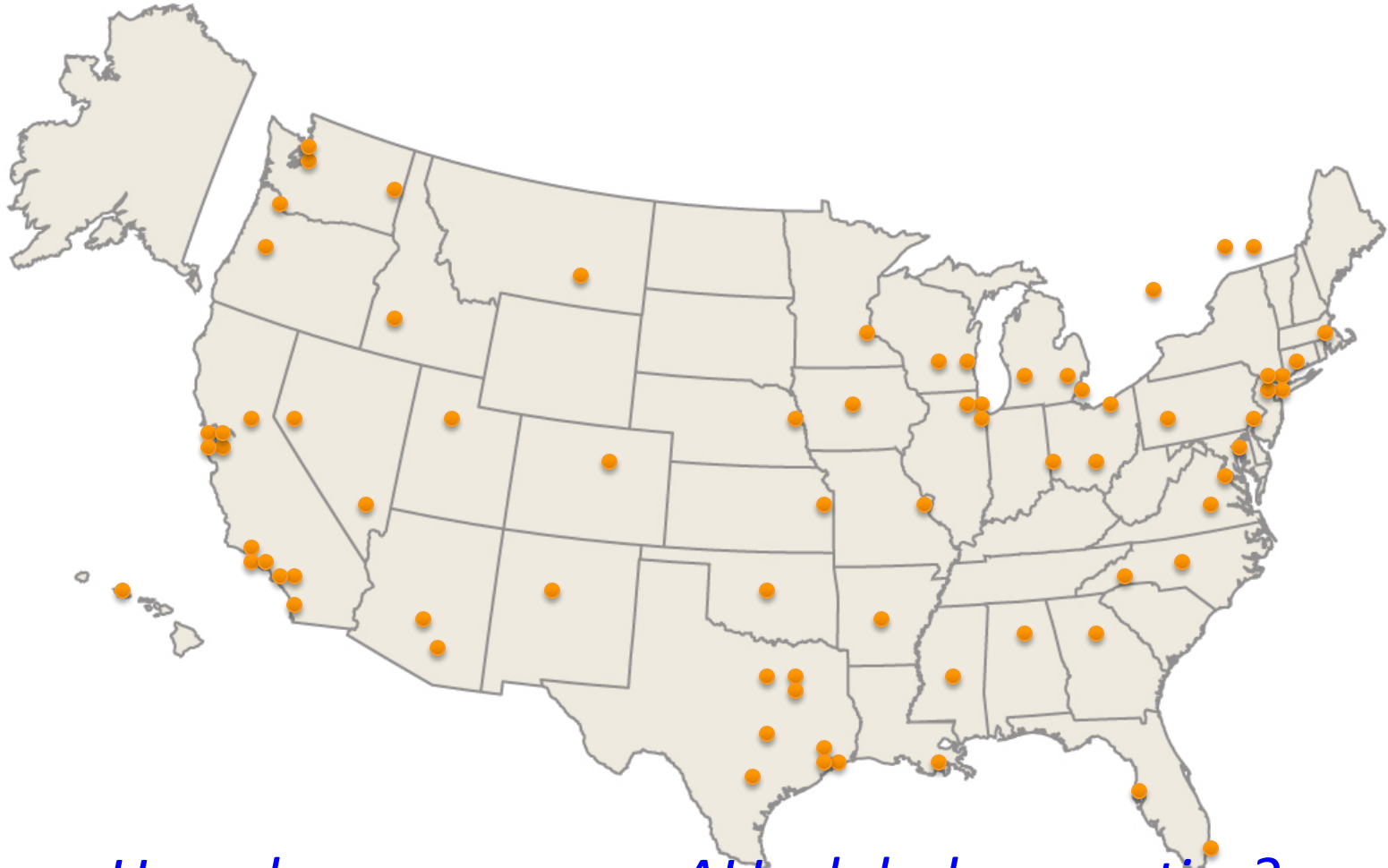
How do you manage ALL global properties?

Beyond the Enterprise:
Smart City. Smart Region.

- Public Transit coordination
- Regional Traffic management
- Parking management
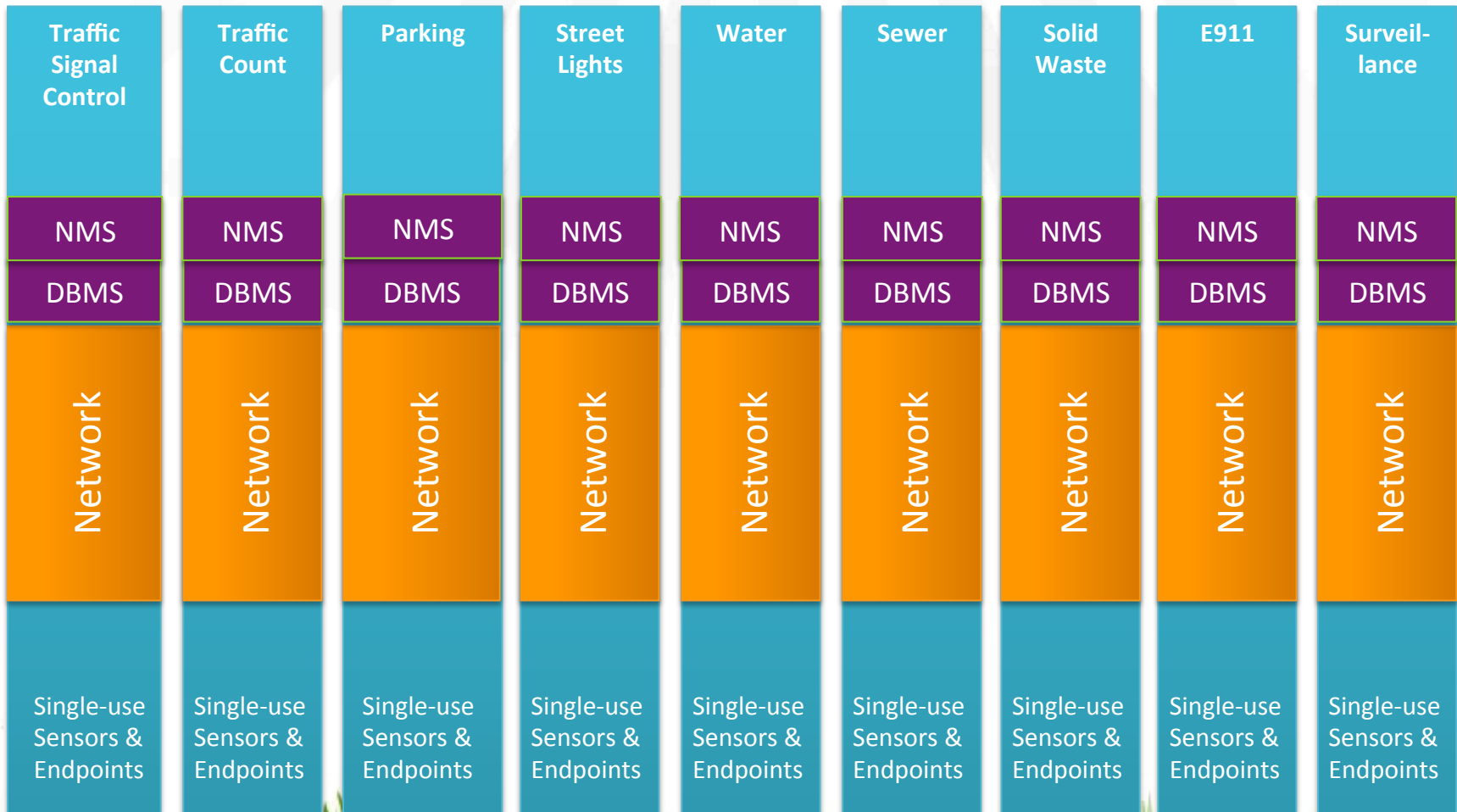- Utility management (power, water, gas)
- Public safety
- Disaster response

- BUT ALSO
- Mobile wayfinding, including pedestrians
- Vehicle to Infrastructure (V2I)
- Retail promotions & advertising

What might this look like?

NB Wireless Network

Muni Fiber Network

Wi-Fi Network

THE CLOUD

Internet
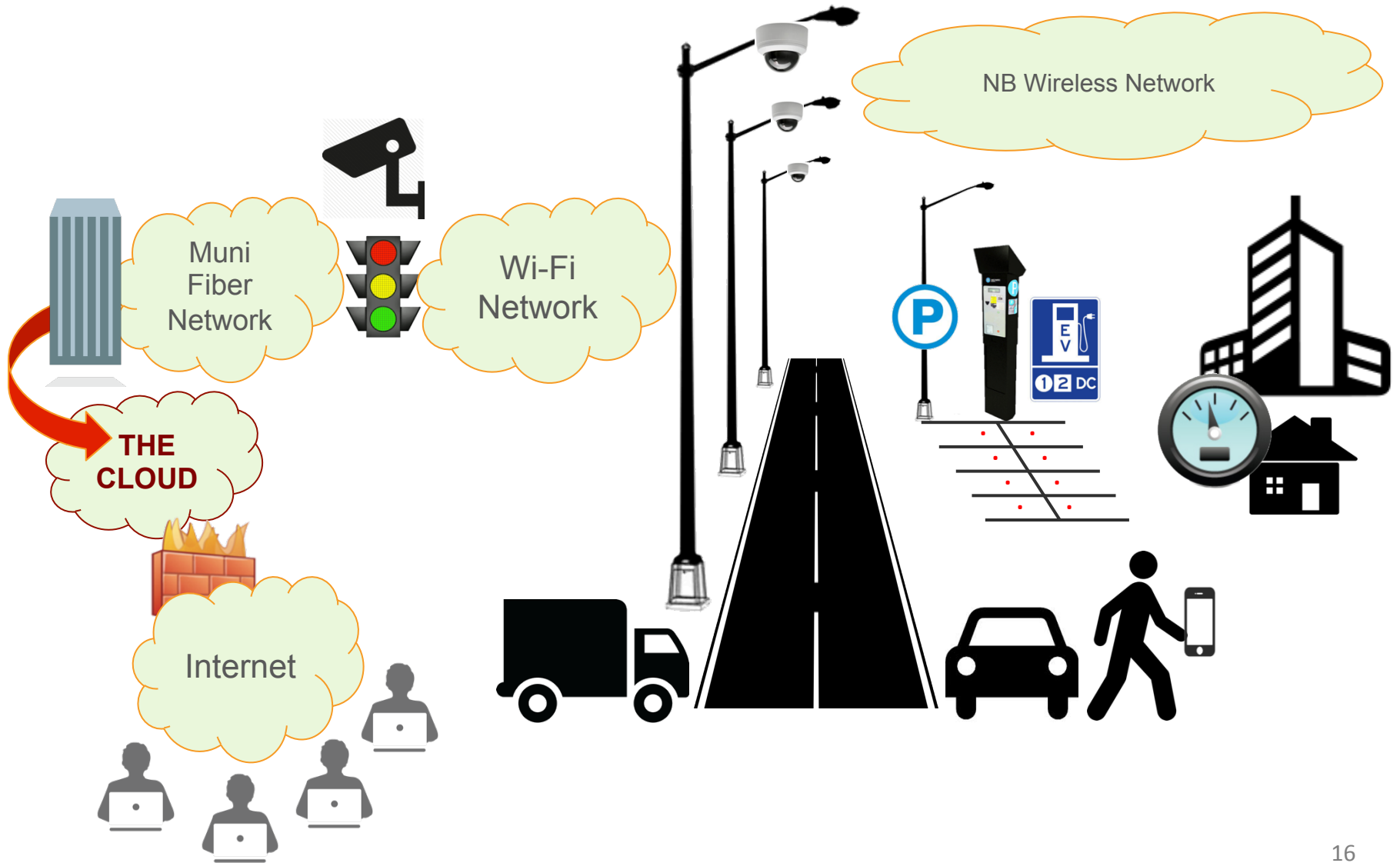
A key challenge: Vertical Applications in Cities

Traffic Signal Control	Traffic Count	Parking	Street Lights	Water	Sewer	Solid Waste	E911	Surveil-lance
NMS	NMS	NMS	NMS	NMS	NMS	NMS	NMS	NMS
DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS	DBMS
Network	Network	Network	Network	Network	Network	Network	Network	Network
Single-use Sensors & Endpoints	Single-use Sensors & Endpoints	Single-use Sensors & Endpoints	Single-use Sensors & Endpoints	Single-use Sensors & Endpoints	Single-use Sensors & Endpoints	Single-use Sensors & Endpoints	Single-use Sensors & Endpoints	Single-use Sensors & Endpoints

Opportunity: Common, Shared Infrastructure

Traffic Signal Control	Traffic Info	Parking Mgmt	Street Light Control	Water Billing & Info	Sewer Mgmt	Solid Waste Mgmt	E911	Surveil-lance

NMS

Cloud-Based Platform

Shared sensor data

Shared Network

Shared-use sensors

| Traffic Signals	Traffic Sensor	Parking Meters & Sensors	Street Lights	Water Meter	Sewer Sensor	Solid Waste Sensor	Panic Button, etc.	Cams & Mics
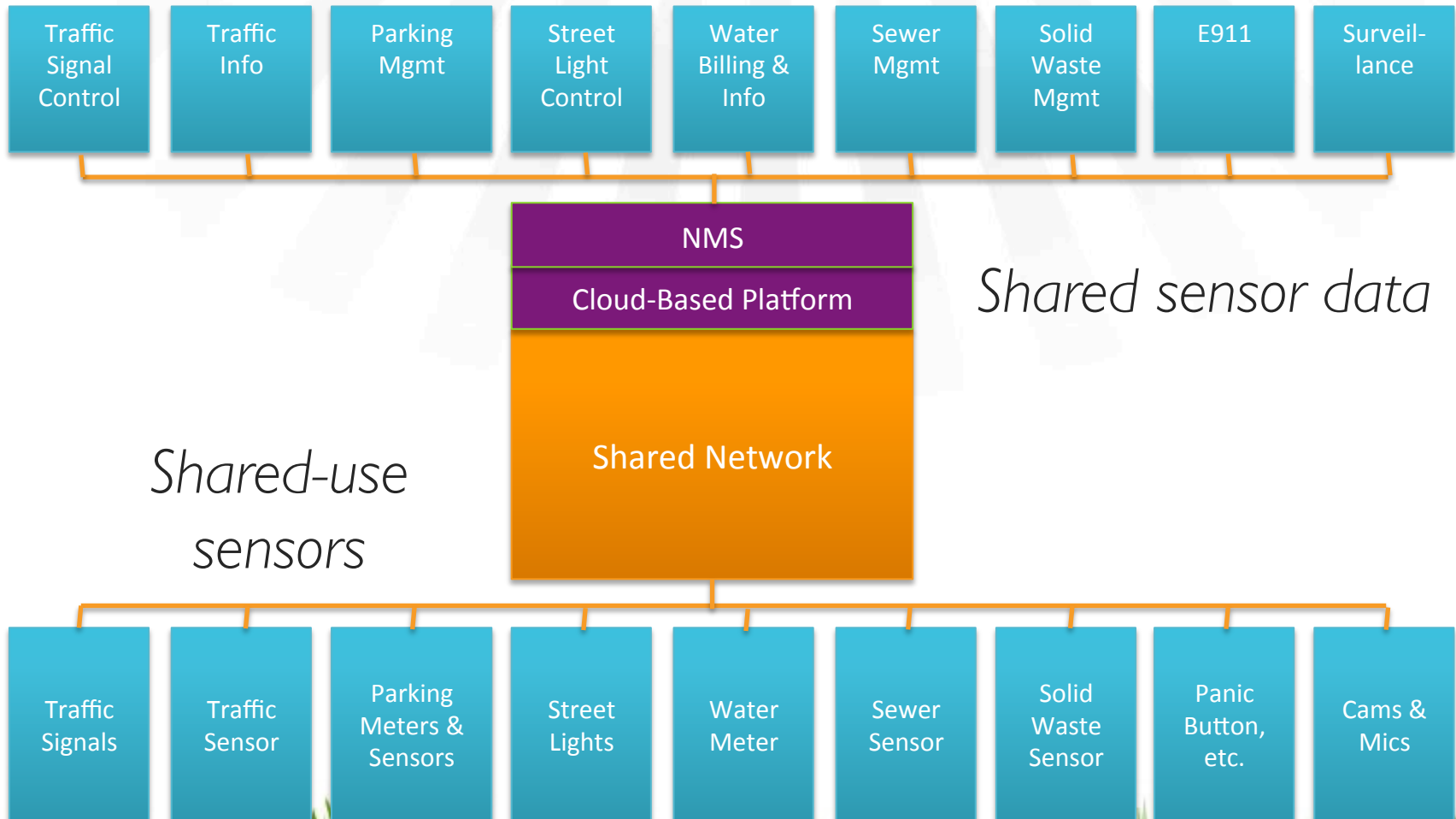
The cloud is a key enabler

Current model

- Each group has its own system, software, hardware, and staff, often one for each application.
- **No Sharing** between budgets
- **Poor Scalability**: requires more real estate, equipment, software, and staff, all of which must be maintained and kept up-to-date.
- Expensive!
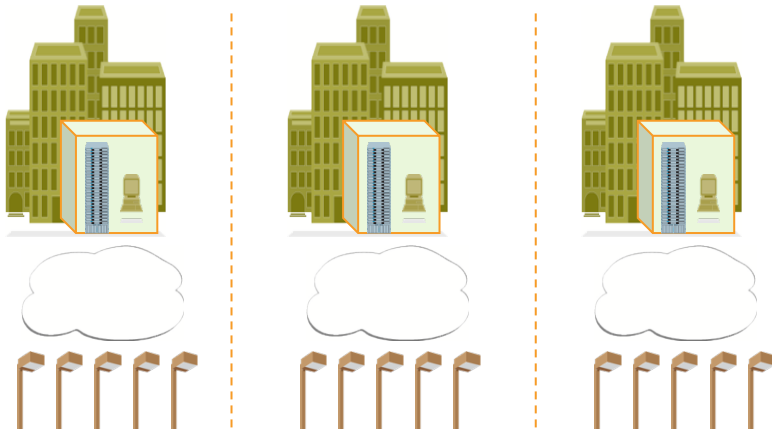
New model

- Single platform, accessible everywhere.
- Automatic updates and backups.
- Better reliability and security.
- Unlimited scalability
- Data sharing possible not only between applications, but also between groups, such as properties, cities and regions, allowing greater insights, better regional coordination, new apps, new features, greater value


NewCo Cloud

2 Benefits & Concerns

Planning and Selection Guidance

Applications and Benefits of IoT: Smart City

Application	Benefits
Street Lighting	Reduced energy cost. Reduced maintenance cost. Healthier lighting. Better security.
Parking	Reduced traffic. Greater convenience. Higher retail sales. Reduced air & noise pollution. Higher property values. Higher tax revenue. Higher parking revenue. Happier citizens.
Traffic Control	Better traffic flow. Shorter commute times. Reduced pollution from idling cars.
Gunshot detection	Reduced crime. Reduced arrest times. Reduced prosecution costs.
Video surveillance	Reduced crime. Higher foot traffic. Increased retail sales. Reduced arrest times. Greater prosecution rates. Reduced prosecution costs. Higher property values.
Retail apps	Increased retail sales. Better understanding of customers. More efficient marketing. Higher retail property values. Higher sales tax revenue

Smart Parking Benefit Map
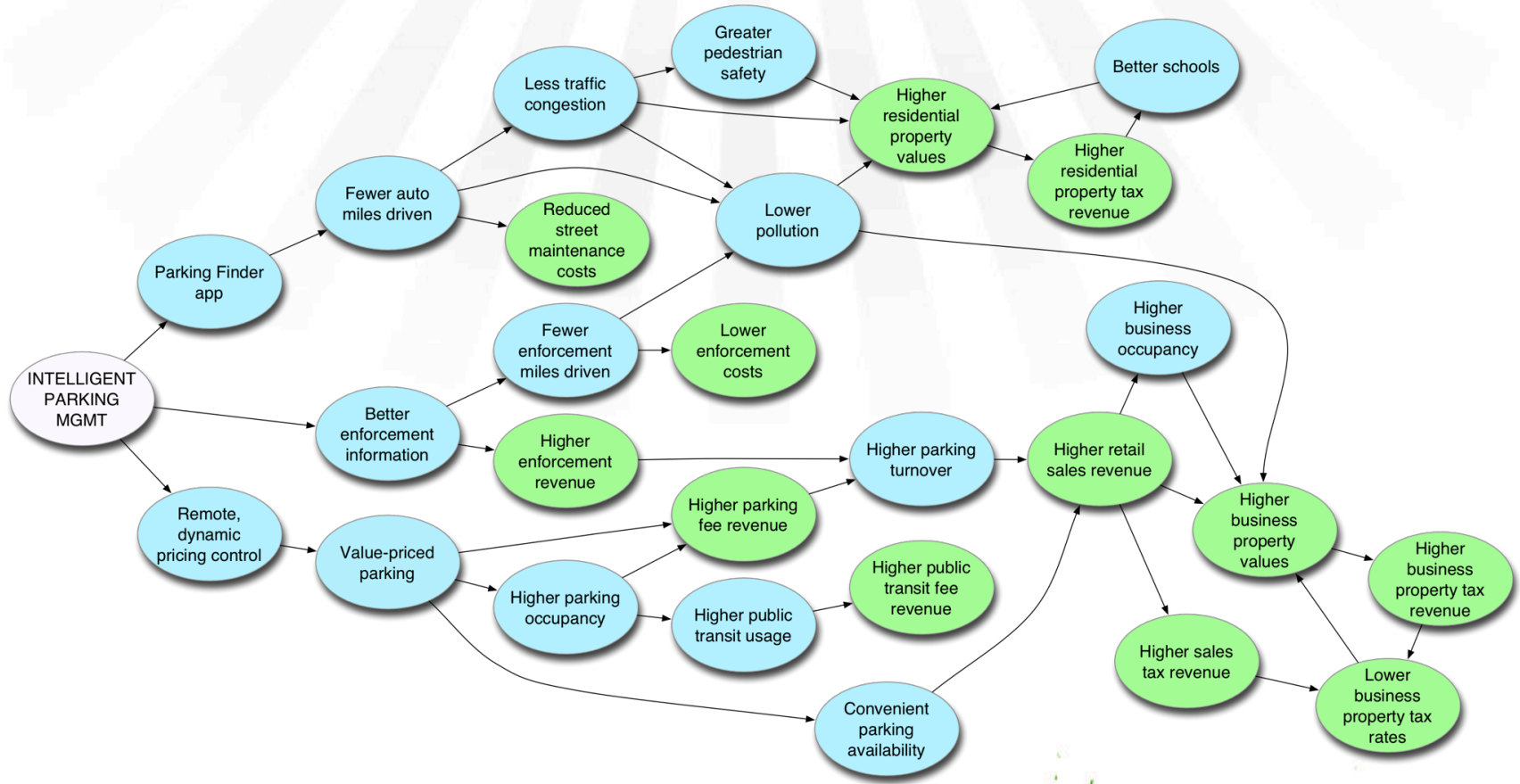
IoT Concerns, both Real and Imagined

Concern	Questions
Benefits	Are they real? To whom do they accrue?
Costs	What they, including purchase, commissioning, operation, and maintenance? How will costs change over time? What is the ROI? How do I pay for it?
Who owns it?	Ownership vs. Lease Financing: advantages of participating in a larger network as a virtual private (or public) network (VPN).
Reliability	Will I become dependent on an unreliable infrastructure? Will the IoT be a single point of failure? Is the network as reliable as the lighting? What are the realistic maintenance assumptions?
Security	Can someone hack into it? If so, what can they do? How can they be forestalled? What is the recovery plan?
Privacy	Will the IoT be spying on me? Do I care, if I am safer and get other benefits?
Compatibility	Is it an open system, using open protocols, languages, and APIs? Does it interoperate with other, existing systems (e.g. BACNet)?

Technical Considerations

Bandwidth	More is needed for longer networks, more apps, bigger data. Dependent on spectrum, power, protocol.
Scalability	How many nodes do I anticipate? Can the network handle it? IPv6 is the protocol of the IoT.
Reliability	Is the technology reliable? Redundant? Meshed?
Latency	Can I get data in real time? Is response time suitable to the application? This is determined by **bandwidth** and **topology**.
Power consumption	Does the additional hardware negate my LED energy savings? Do I need AC? Related to **bandwidth**, **range**, **compute-intensity**.
Flexibility	Is the solution truly an open, application-enabling IoT platform? Is it modular? Can I upgrade without replacing my entire infrastructure?
Timing	Do I build it all now, or build a little now and hope for future improvements and costs reductions? (see "future proof")
Cost	As usual. More is more. Is less enough?

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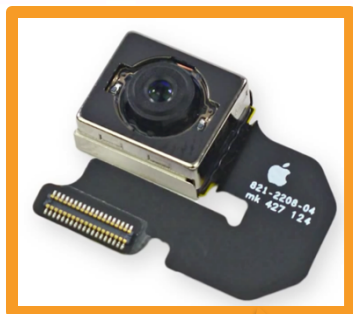**3** **Technologies**

Places and Vendors

Why Now? – Emerging Technologies

Technology	Advancements
Microprocessors	Moore's Law = tiny, low-power, inexpensive, reliable
Memory	Moore's Law = (ditto)
Wireless	802.11, 802.15.4, BLE, ARFID, 6LoWPAN, 4G, GPS, EnOcean, …
Cloud	Virtualization, SDN, IaaS, PaaS, SaaS
Big Data	NoSQL, Hadoop, MongoDB, …
Sensors	**Video** for occupancy, light level, count, speed, identification, … **Audio** for gunshots, crashes, crowds, help!, etc. **Accelerometer, GPS, temp, humidity, CO2/O2, methane, …**
Other stuff	Grid computing & distributed computing, machine learning, local vs. cloud computing, real-time analytics, pattern recognition, node cooperation, …

Apple iPhone 6 Guts

8mp camera

Processor, memory
Motion co-processor
NFC + security chips
Bluetooth, Wifi, GPS
Gyro+Accelerometer
Vibrator

$60-100 part cost?

Technologies Jay Likes

Technology Area	What, and Why I like it
802.11 (Wi-Fi)	Cheap. Lots of bandwidth. Standard. But power hungry and short range.
802.15.4	Cheap, standard MAC layer for low power wireless
6LoWPAN	IPv6 based IETF open standard replaces Zigbee. Long range but low speed in sub-GHz bands.
Bluetooth Low Energy (BLE)	Cheap. Low power. Fast. Ubiquitous; already in smart phones. Great for many apps involving location, health, payments, many others.
Video in General	One sensor for occupancy, light level, trajectories, event recording, and eventually vehicle and face recognition. Can be secure!
Audio	Cheap way to know what is going on, especially bad things!
Accelerometer	Cheap! Can sense car hitting pole, thief stealing wires, heavy vehicles, high wind, explosions, and earthquakes.
Temperature	Cheap! One way to understand environment at a granular level, including heat islands (outdoor), occupancy (indoor), etc.
CO2/gasses	Not cheap, but great for monitoring pollution and gas leaks

Lessons

- The IoT will happen; resistance is futile.
- Lighting is a great host for IoT nodes.
- YOU can participate in this revolution.

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Thank You!

Let me know if I can help.