

Chapter 2

IoT applications

ADVANCED TOPICS IN DATA SCIENCE

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Outline

- 1.Smart cities
- 2.Smart Grid
- 3.Healthcare
- 4.Agricultural and environmental
- 5.Supply chain
- 6.Government and military

1. Smart cities

- Smart cities use the Internet of Things to improve the quality of citizens' lives. They **connect the unconnected**, and manage assets and resources as efficiently as possible, with a view to economic, social, and environmental sustainability.



1.Smart cities

Main Components

- **Sensors** that monitor the condition of utilities such as electricity, water supply, load on surface transport and capture real-time data. A smart camera installation on each street corner in New York would require over 3,000 cameras. In other cases, a city such as Barcelona will deploy nearly one million environmental sensors to monitor electric usage, temperature, ambient conditions, air quality, noise levels, and parking spaces. These all have low bandwidth needs versus a streaming video camera, but the aggregate amount of data transmitted will be nearly the same as the surveillance cameras in New York. These characteristics **of quantity and bandwidth** need to be considered in building the correct IoT architecture.
- **Gateways** that aggregate real-time data from these sensors, perform local analytics and based on the result, take localized action to prevent possible faults from further propagating into the networks;
- **Communication infrastructure** to connect these gateways to server cloud for transmitting data on condition of local area;
- **Server farms in a cloud based architecture** that warehouses the data; performs real-time mining of such data to provide useful information to various stakeholders through various channels such as mobile devices.

1.Smart cities

Smart city IoT use cases

Some of the smart city IoT use cases are as follows:

- Pollution control and regulatory analysis through environmental sensing
- Microclimate weather predictions using citywide sensor networks
- Efficiency gains and improved costs through waste management service on demand
- Improved traffic flow and fuel economy through smart traffic light control and patterning
- Energy efficiency of city lighting on demand
- Smart snow plowing based on real-time road demand, weather conditions, and nearby plows
- Smart irrigation of parks and public spaces, depending on weather and current usage
- Smart cameras to watch for crime and real-time automated emergency Alerts
- Smart parking lots to automatically find best space parking on demand
- Bridge, street, and infrastructure wear and usage monitors to improve longevity and service

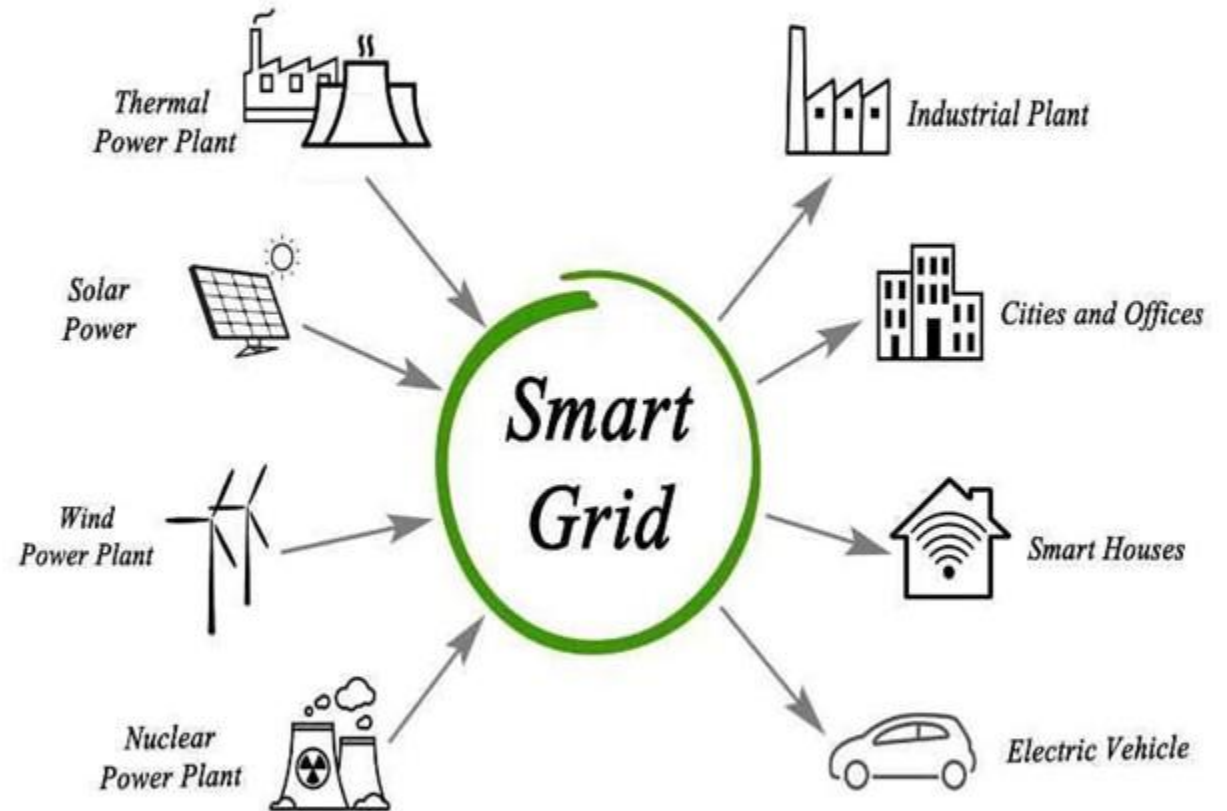
1.Smart cities

Example: Barcelona

- Barcelona is an excellent example of a smart city. For example:
 - They monitor trash containers and bins for pickup based on the current capacity, but also the time since the last pickup. This improves the trash collection efficiency allowing the city to use fewer resources and tax revenue in transporting waste, but also eliminates potential smells and odors of rotting organic material.
 - They have an app that helps direct drivers to an available parking spot.
 - Street lights traditionally provide safety at night, but smart systems can sense when they don't need to be on and therefore save energy and money. Rather than routinely replacing thousands of lights, maintenance can be specific to lights that are broken or about to break.
- Smart cities are also impacted by government mandates and regulations, therefore there are ties to the government segment.

2. Smart Grid

- The smart grid is a communication network on top of the electricity grid to gather and analyze data from different components of a power grid to predict power supply and demand which can be used for power management



2. Smart Grid

- The existing Grid is limited in its one-way interaction; which makes it difficult for the grid to respond to the ever-changing and rising energy.
- **The smart grid introduces a two-way dialogue** where electricity and information can be exchanged between the utility and its customers; it's a developing network of communications, automation and new technologies and tools working together to make the grid more efficient, more reliable, more secure.



2. Smart Grid

Main Components

- **Smart appliances:** Smart appliances will be able to respond to signals from your energy provider to avoid using energy during times of peak demand. This is more complicated than a simple on and off switch. For instance, a smart air conditioner might extend its cycle time slightly to reduce its load on the grid; while not noticeable to you, millions of air conditioners acting the same way could significantly reduce the load on the power grid. Likewise, a smart refrigerator could defer its defrost cycle until off-peak hours, or a smart dishwasher might defer running until off-peak hours. These tech appliances have an important impact on the grid generators since they help in understanding the power position and reduce the peak load factors.
- **Smart meters:** The smart meters are a two-way communicator that help create a bridge between the power providers and the end consumer. It automates the billing data collection on the very convenient manner, detects system failures and sends power outage notification.



2. Smart Grid

Main Components

- **Smart substations:** Substations are located in every region as sub-branch for their main station. They monitor the performance of the station and control any critical and non-critical data that could be the status of the power, power performance, circuit breakers, security and the operationalization of the transformers. These are also used to transform voltage at several stations and operational regions and to split the path of electricity into several routes. Smart grid's substations require heavy equipment and manpower to be operationalized thoroughly. This equipment may include transformers, switches, capacitor banks, circuit breakers and a network protected relay.
- **Phasor measurement technology :** Phasor measurement is a technology that can help maintain stability in the power grid. A phasor measurement unit (PMU) is a device that measures electrical waveforms on the electrical grid.

2. Smart Grid

Smart Grid and renewable energy

- The smart grid enables newer technologies to be integrated such as wind and solar energy production and plug-in electric vehicle charging with our participation as informed consumers this smart grid will replace the aging infrastructure of today's grid and utilities can better communicate with us to help manage our electricity needs the smart home communicates with the grid and enables consumers to manage their electricity usage by measuring a home's electricity consumption more frequently
- Renewable power sources are variable by nature and add complexity to normal grid operations the smart grid provides the data and automation needed to enable solar panels and wind farms to put energy onto the grid and optimize its use to keep up with constantly changing energy demands utilities must turn power plants on and off depending on the amount of power needed at certain times of the day

3. Healthcare

- With real-time monitoring of the condition in place by means of a smart medical device connected to a smartphone app, connected devices can collect medical and other required health data and use the data connection of the smartphone to transfer collected information to a physician.
- Center of Connected Health Policy conducted a study that indicates that there was a 50% reduction in 30-day readmission rate because of remote patient monitoring on heart failure patients.
- The IoT device collects and transfers health data: blood pressure, oxygen and blood sugar levels, weight, and ECGs.
- These data are stored in the cloud and can be shared with an authorized person, who could be a physician, your insurance company, a participating health firm or an external consultant, to allow them to look at the collected data regardless of their place, time, or device.

3. Healthcare

Some of the healthcare IoT use cases are as follows:

- In-home patient care
- Learning models of predictive and preventative healthcare
- Dementia and elderly care and tracking
- Hospital equipment and supply asset tracking
- Pharmaceutical tracking and security
- Remote field medicine
- Drug research
- Patient fall indicators

3. Healthcare

Case study: Real-time monitoring of patients

- Reducing the time needed for patient care in the hospitals
- More places in hospitals for people in the greatest need
- Improved patients' comfort
- Alerts in event of life-threatening circumstances



4. Agricultural & Environmental

- Farming and environmental IoT includes elements of livestock health, land and soil analysis, micro-climate predictions, efficient water usage, and even disaster predictions in the case of geological and weather-related disasters. Even as the world population growth slows down, world economies are becoming more affluent. Hunger and starvation crises are rare. That said, the demand for food production is set to double by 2035. Significant efficiencies in agriculture can be achieved through IoT.
- Using smart lighting to adjust the spectrum frequency based on poultry age can increase growth rates and decrease mortality rates based on stress on chicken farms. Additionally, smart lighting systems could save \$1 billion annually on energy versus the common dumb incandescent lighting currently used.
- Other uses include detecting livestock health based on sensor movement and positioning. A cattle farm could find animals with the propensity of sickness before a bacterial or viral infection were to spread. Analysis systems could find, locate, and isolate heads of cattle in real time, using data analytics or machine learning approaches.
- This segment also has the distinction of being in remote areas (volcanoes) or sparse population centers (corn field).
- This has impacts on data communication systems that we will need to consider in later Chapters

4. Agricultural & Environmental

Some of the agricultural and environmental IoT use cases are as follows:

- Smart irrigation and fertilization techniques to improve yield
- Smart lighting in nesting or poultry farming to improve yield
- Livestock health and asset tracking
- Preventative maintenance on remote farming equipment via manufacturer
- Drones-based land surveys
- Farm-to-market supply chain efficiencies with asset tracking
- Robotic farming
- Volcanic and fault line monitoring for predictive disasters

4. Agricultural & Environmental

Case study: Drones-based land surveys

Crop status, irrigation requirements, spraying are important in the agricultural sector. Data collected with the drone reduces the time the smart farm manager devotes to daily work. The drone provides thermal and perspective viewing while flying on the farm. Drones can send many values such as plant height measurement, daily yield estimates, land values to the user with the imaging system.



5. Supply chain management (SCM)

- In the supply chain, Internet of Things devices are an effective way to track and authenticate products and shipments using GPS and other technologies. They can also monitor the storage conditions of products which enhances quality management throughout the supply chain.

5. Supply chain management (SCM)

IoT devices have revolutionized supply chain management (SCM). It's much easier to understand where goods are, how they are being stored and when they can be expected at a specific location.

- **Authenticate the Location of Goods at Any Time:** IoT devices can be attached to specific storage containers or to raw materials or products themselves. The IoT device will transmit its location, which can be picked up by GPS satellites and used to track movement of goods.
- **Track Speed of Movement and When Goods Will Arrive:** Tracking speed of movement and the traffic flow of products makes it much easier to predict how goods will move through the supply chain. Suppliers, manufacturers and distribution centers can prepare to receive goods, which reduces handling times and ensures the efficient processing of materials.
- **Monitor Storage Conditions of Raw Materials and Products:** Some goods like food and chemicals need to be stored in ideal conditions. Specialist IoT devices can monitor areas like temperature, humidity, exposure to an atmosphere, light intensity and other environmental factors. These devices may even trigger an alarm if certain thresholds are breached. This makes it much easier to track the quality of goods through the supply chain and to reduce spoilage.
- **Streamline the Problematic Movement of Goods:** Goods tracking and route planning through IoT devices can identify where and when goods are delayed in transit. This allows for contingency planning and alternative routes to speed up the supply chain.
- **Locate Goods in Storage:** Goods can remain tagged with IoT devices when they are in a distribution center. This can make it much easier to find specific products within a large warehouse and ensures accurate identification and management of goods.
- **Administer Goods Immediately Upon Receipt:** Verified tracking through IoT devices means that SCM can validate exactly when goods arrive. This can trigger other administrative tasks like supplier payments.

6. Government and military

- Some uses include projects like the Internet Battlefield of Things, with the intent of providing efficiencies for friendly, personal, and counter-attacks on enemies.
- This segment also ties into the smart city category when we consider the monitoring of government infrastructures like highways and bridges.
- The government's role in the IoT also comes into play in the form of standardization, frequency spectrum allocation, and regulations. Take, for example, how the frequency space is divided, secured, and portioned to various providers.

6. Government and military

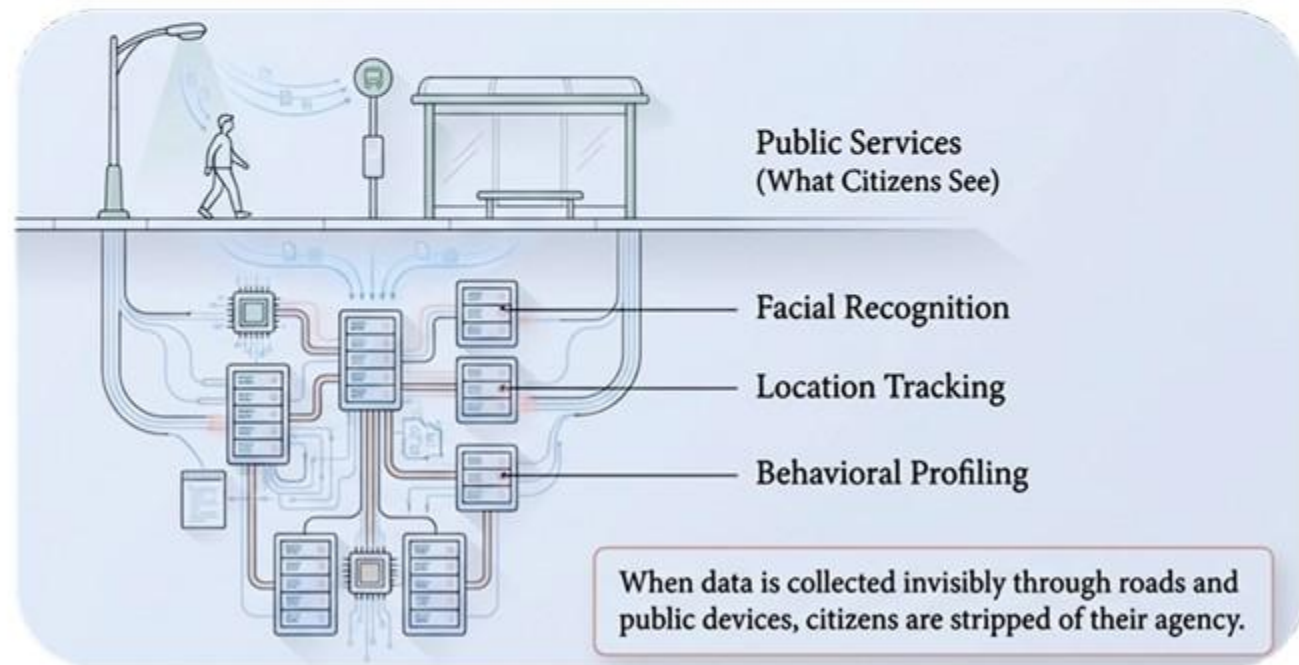
Following are some of the government and military IoT use cases:

- Terror threat analysis through IoT device pattern analysis
- Swarm sensors through drones
- Sensor bombs deployed on the battlefield to form sensor networks to monitor threats
- Government asset tracking systems
- Real-time military personal tracking and location services
- Synthetic sensors to monitor hostile environments
- Water level monitoring to measure dam and flood containment

Ethical Implications of Smart Cities

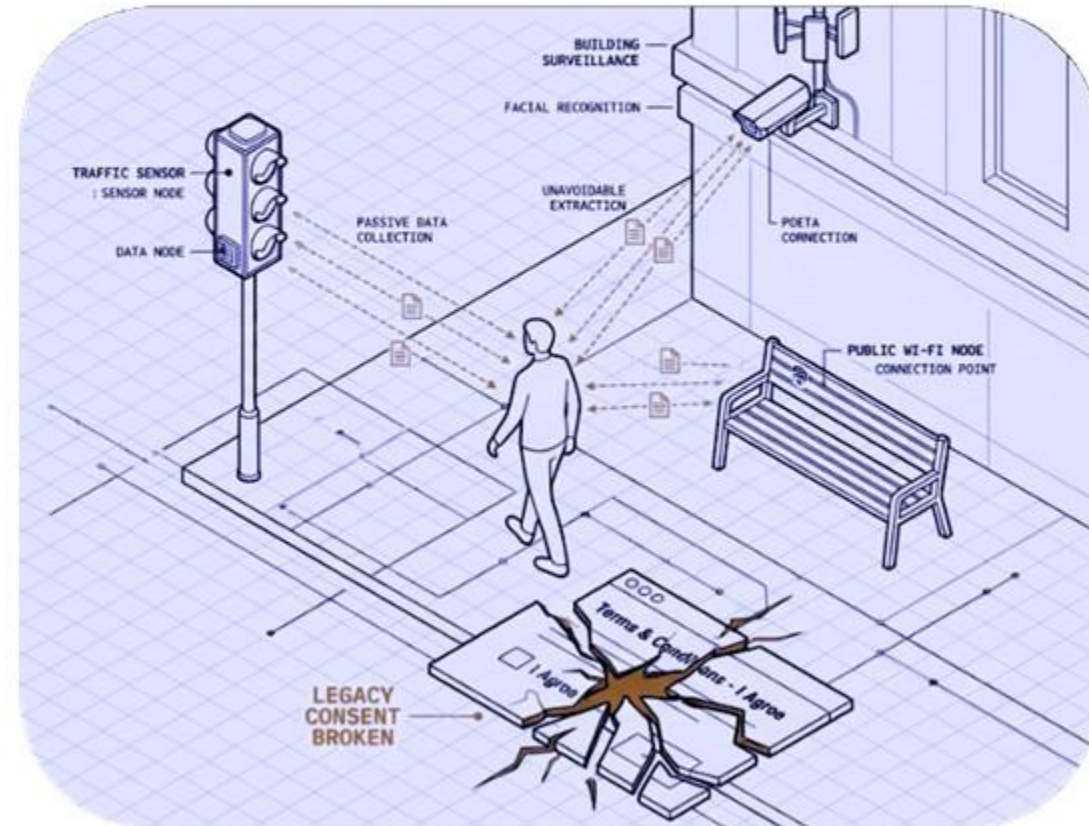
Balancing Technology and Citizen Rights

1. Ethical Concerns
2. Real-World Implications
3. Case Studies
4. How to Build Ethical Smart Cities



Ethical Concerns

- Privacy & Surveillance: constant monitoring, facial recognition, personal data collection
- Algorithmic Bias: historical data may reinforce inequalities
- Transparency & Accountability: complex systems are hard to understand
- Consent: invisible data collection limits informed choice
- Power Imbalance: data controlled by government/companies



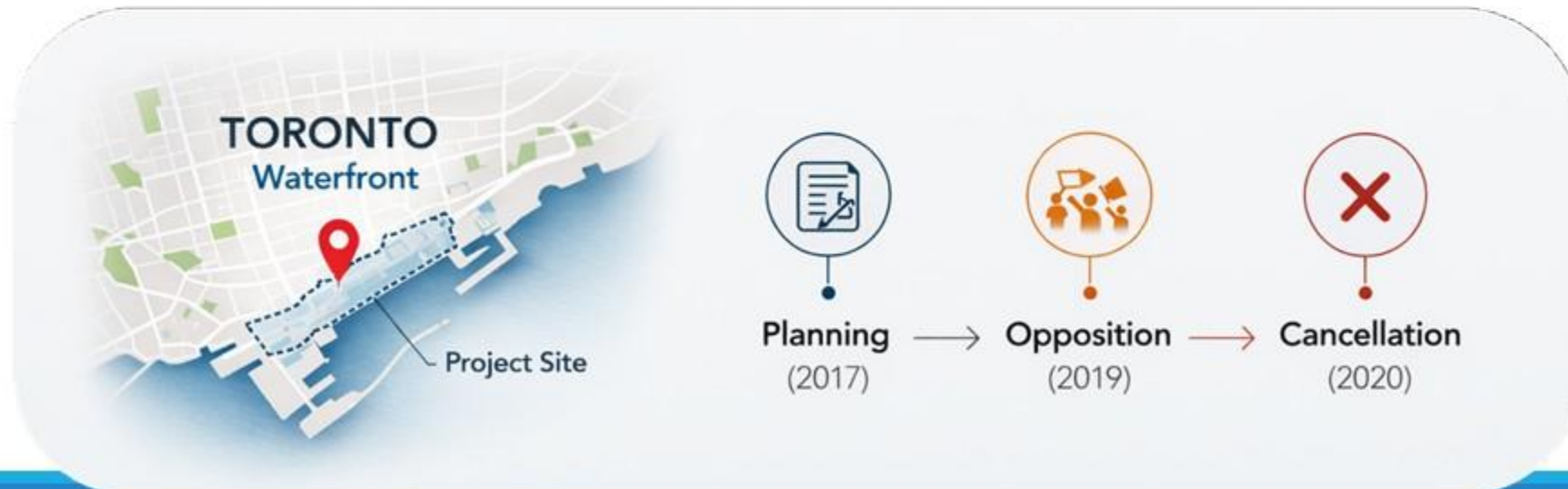
Real-world implications

- Data Privacy & Security Risks: cyberattacks, misuse of personal data
- Impact on Daily Life: constant monitoring affects behavior & freedom
- Digital Inequality: unequal access to technology
- Trust in Authorities: lack of transparency reduces cooperation
- Security & Financial Risks: identity theft, financial loss

Case Studies (1): Toronto Smart City (Sidewalk Labs)

- Planned “digital city” on waterfront
- Public concern: unclear data ownership & privacy rules
- Project canceled due to opposition

Key Lesson: Public trust is crucial



Case Studies (2): SmartSurveillancein China

- Uses facial recognition & AI to monitor citizens
- Improves efficiency & safety
- Criticized for limiting freedom & giving government excessive control

Key Lesson: Technology must respect citizens' rights



How to Build Ethical Smart Cities

Technological Sovereignty: prioritize citizens, public data ownership

Privacy-by-Design: protect rights from start

Citizen Participation: include residents in decision-making

Open Data: transparency builds trust

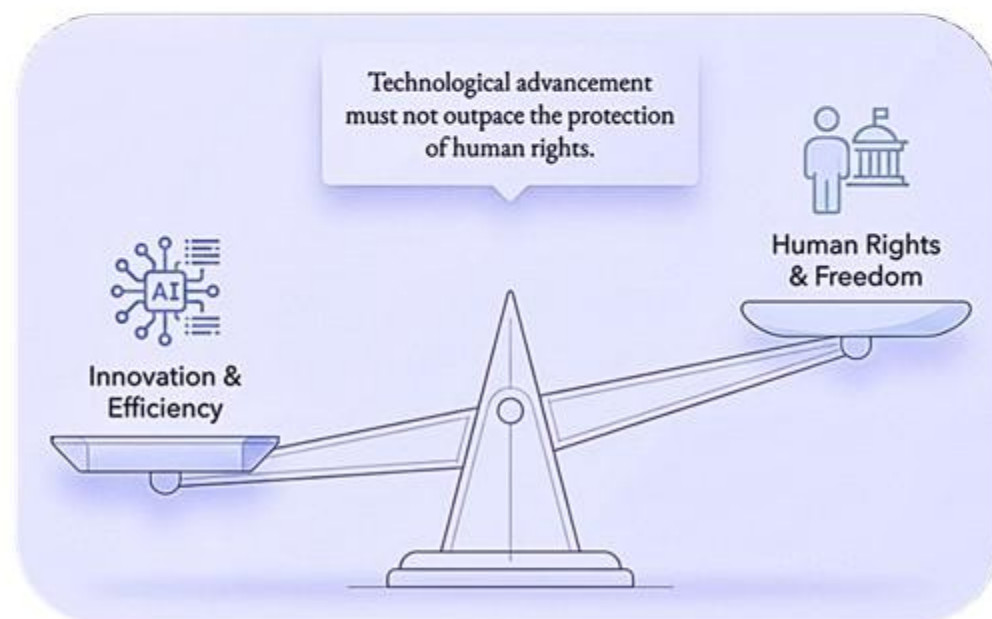
Independent Oversight: ethical boards to monitor projects

Transparent Testing: controlled “living labs” before deployment



How to Build Ethical Smart Cities

- Smart cities can improve urban life through better services, infrastructure, and safety
- They raise ethical challenges like privacy, bias, and unequal access.
- Prioritizing citizen rights, transparency, and oversight ensures these cities enhance quality of life while protecting freedom, trust, and fairness.



Questions