CANARA ENGINEERING COLLEGE

BANTWAL, MANGALURU 574219

COMPUTER SCIENCE & ENGINEERING

CLASS

Computer Learning Adventure in Social Sphere

COURSE TITLE (CODE)	Internet of Things 17CS81
MODULE/ CHAPTER	MODULE 5
TOPICS	IOT Physical Devices and End Points: Arduino UNO
FACULTY	SHRISHA H.S.

"QUALITY EDUCATION AT AFFORDABLE COST"

Module-4

Topic: IOT Physical Devices and Endpoints

SHRISHA H.S.

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DEPARTMENT OF CS&E

CANARA ENGINEERING COLLEGE

IOT Physical Devices and Endpoints

- **Arduino UNO**
- **Raspberry Pi**
- **Smart and Connected Cities**

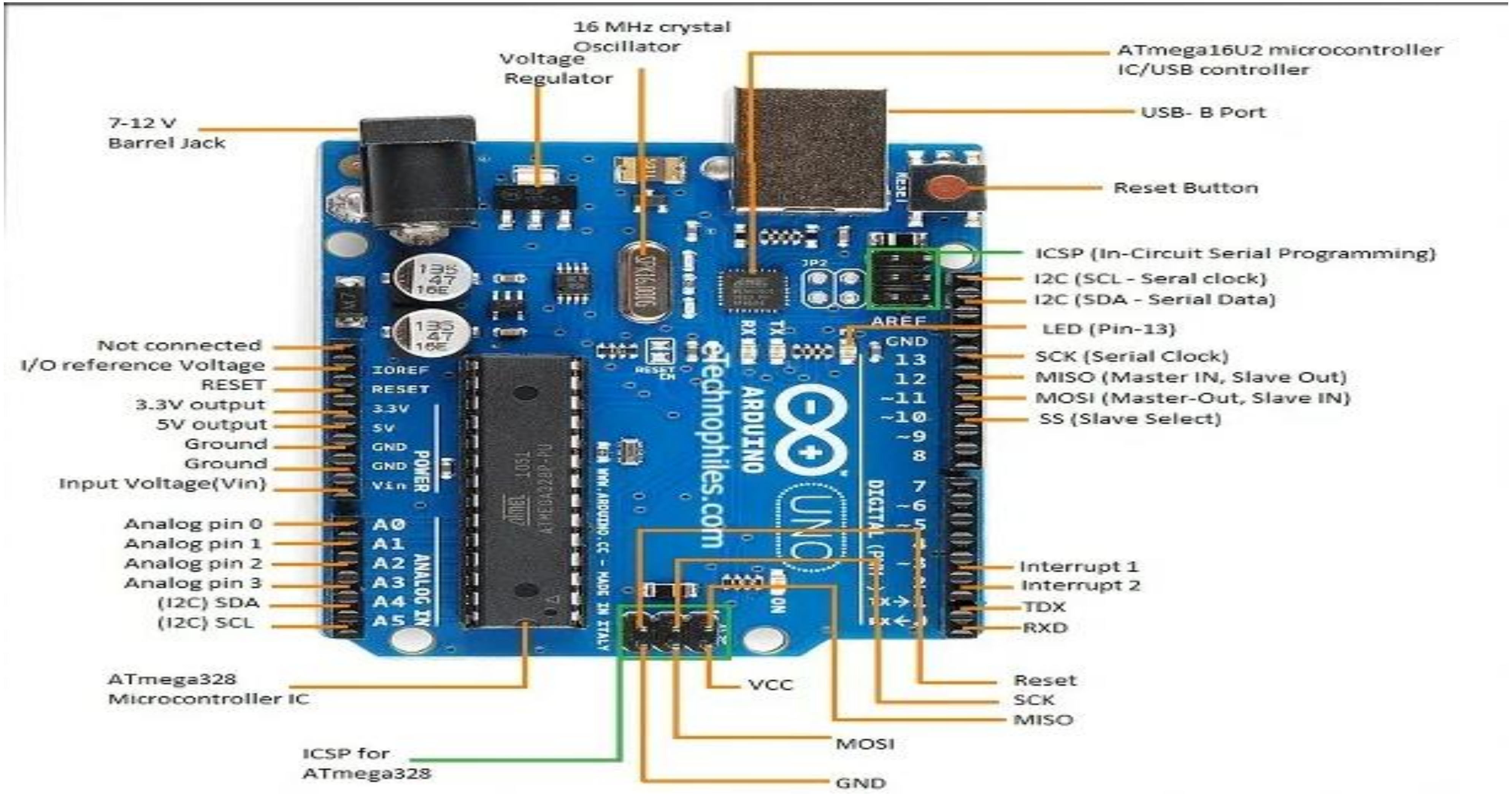
Arduino UNO

- Introduction to Arduino
- Arduino UNO
- Installing the Software
- Fundamentals of Arduino Programming

Arduino : Introduction

- Arduino is an open-source prototyping platform with programming facility.
- Arduino can read input-detecting power of light, trigger events.
- Arduino is a small computer which can be used to read input and produce output.
- Arduino is an open-source platform which is flexible and accessible to customers.
- Arduino can be connected to electrical circuits and have USB, communicates through serial protocol.
- Arduino is cross-platform which works with Mac, Windows and Linux OS
- Arduino family has Mega, Flora,MKR1000, Micro, UNO variants.

Arduino UNO



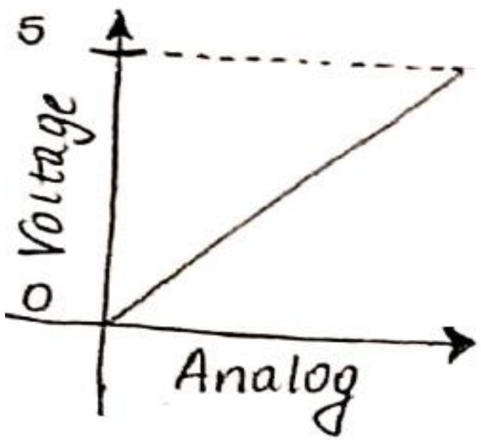
16 MHz crystal Oscillator
Voltage Regulator
ATmega16U2 microcontroller IC/USB controller
USB- B Port
7-12 V Barrel Jack
Reset Button
ICSP (In-Circuit Serial Programming)
I2C (SCL - Seral clock)
I2C (SDA - Serial Data)
LED (Pin-13)
SCK (Serial Clock)
MISO (Master IN, Slave Out)
MOSI (Master-Out, Slave IN)
SS (Slave Select)
Not connected
I/O reference Voltage
RESET
3.3V output
5V output
Ground
Ground
Input Voltage(Vin)
Analog pin 0
Analog pin 1
Analog pin 2
Analog pin 3
(I2C) SDA
(I2C) SCL
Interrupt 1
Interrupt 2
TDX
RXD
ATmega328 Microcontroller IC
VCC
Reset
SCK
MISO
MOSI
ICSP for ATmega328
GND

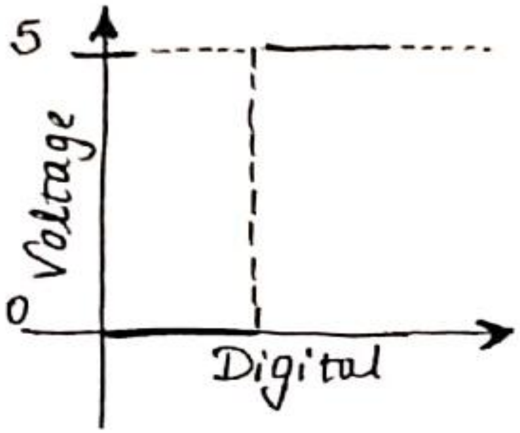
Arduino UNO

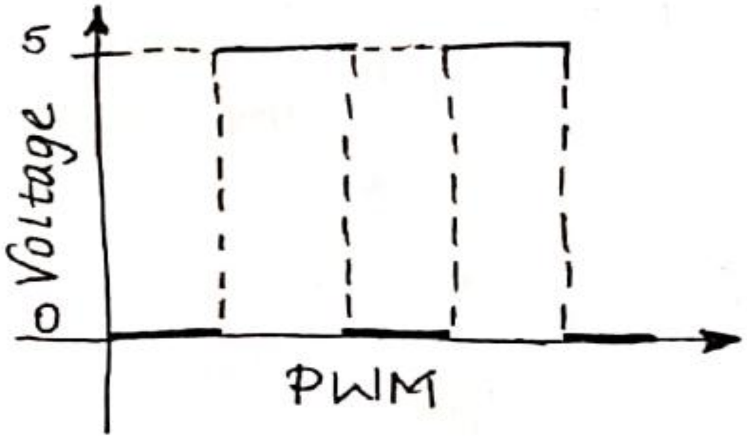
- Micro-controller: ATmega328
- Digital Pins:14 digital pins, labeled 0 to 13 that act as input or input.
- PWM Pins: 3,5,6,9,10,11. PWM(Pulse with Modulations)
- TX and RX pins: T for transmit, R for Receive.
- Analog Pins: A0 to A5- to read analog inputs.
- Power Pins: 3.3V or 5V
- Reset Button: Program being currently run is restarted.
- USB Jack
- Power Jack
- Sensors that can be connected to arduino are: Motion sensor, Light sensor, humidity and temperature sensor, ultrasonic sensor.

Arduino UNO

Analog	Digital	PWM
0 to 1023 states can be identified	Only binary states: 0 & 1	0V or 5V
Applicable to analog light sensor	Applicable to digital devices i.e LED	Can simulate voltage between 0V and 5V







Arduino UNO: Installing the software

- Arduino IDE(Integrated Development Environment)
- Selecting the OS

Arduino UNO: Fundamentals of Arduino Programming

Structure

```
Void setup()
 {
  Statement(S);
 }
Void loop()
 {
  digitalWrite(pin, HIGH);
  delay(10000);

  digitalWrite(pin ,LOW);
  delay(10000);
 }
```

Arduino UNO: Fundamentals of Arduino Programming

- Functions: Syntax

```
type functionName(parameters)
{
Statement(S);
}
```

Variable:

```
int x=14;
```

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Computer **L**earning **A**dventure in **S**ocial **S**phere

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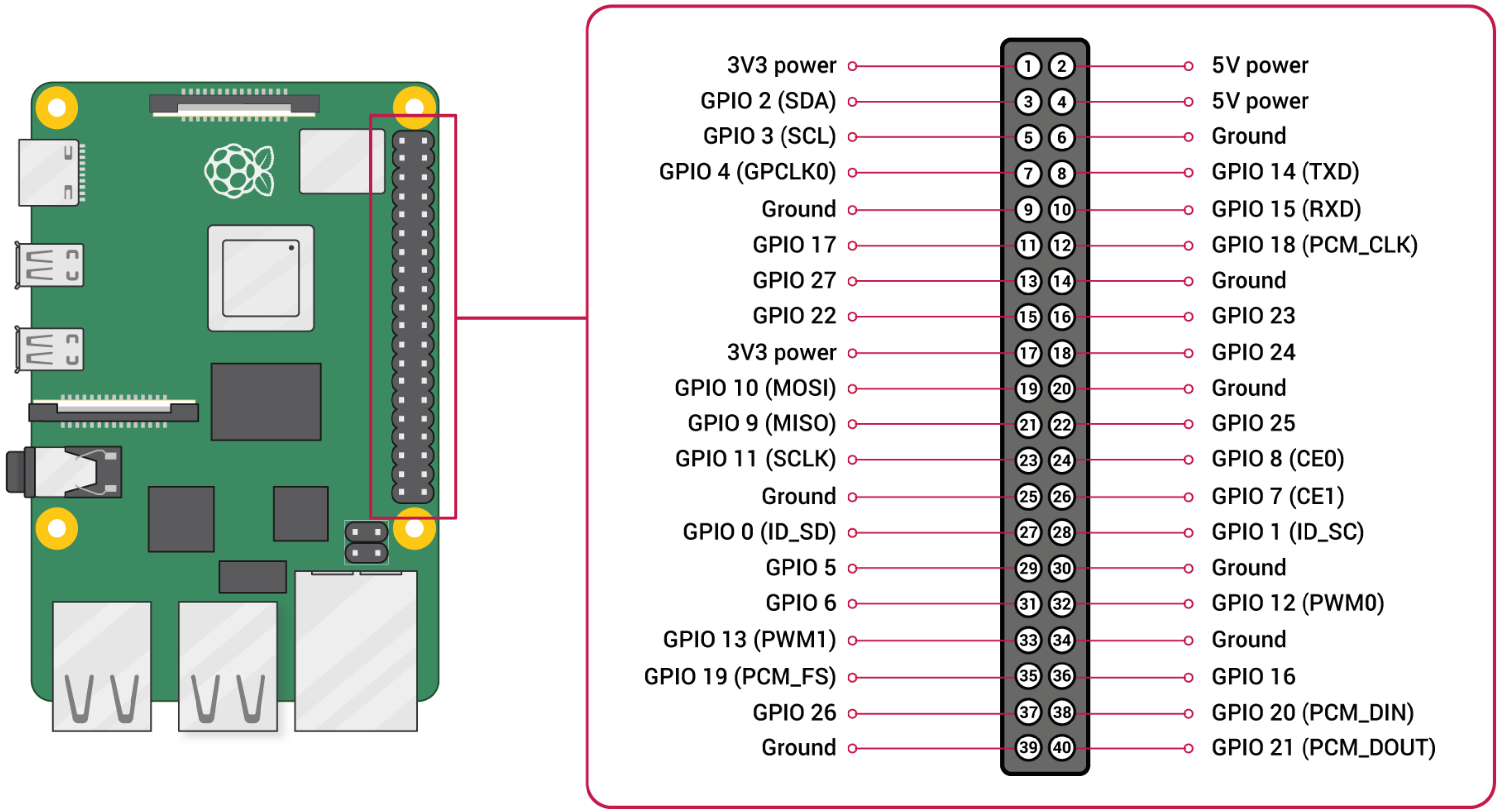
IOT Physical Devices and Endpoints

- **Arduino UNO**
- **Raspberry Pi**
- **Smart and Connected Cities**

Raspberry Pi

- Raspberry pi is single board computer developed to teach computer science in education institutions.
- Became popular in applications like robotics.
- Raspberry pi is inexpensive, open-source, cross-platform.

Raspberry Pi



Raspberry Pi

- Processor: Broadcom BCM2711
- Power Source: Micro USB
- SD card: Raspberry Pi does not have inbuilt local storage. Working framework is embedded on SD card.
- GPIO(General Purpose Input Output):GPIO is a non-specific IO pins which can be controlled by clients during runtime.
- DSI display X: Connector S2 is Display Serial Interface(DSI) to connect LCD display.
- Audio jack: 3.5mm TRS connector.
- Ethernet Port
- CSI connector: Camera Serial Interface(CSI) is a serial interface outlined by Mobile Industry Processor Interface(MIPI).

Raspberry Pi

- Raspberry Pi interfaces
  - Serial: Receive(Rx) and Transmit(Tx)
  - SPI: Serial Peripheral Interface is a synchronous serial communication interface
  - I2C pins: Allows to connect to hardware modules. I2C pins allow synchronous data transfer with SDA(data line) and SCL(clock line)

Raspberry Pi

- Operating System
  - Linux based
    - Kali Linux
    - Raspbian
    - Cent OS
  - Non-linux based
    - Free BSD
    - Net BSD
  - Media center OS
    - Rasplex
    - LibreELEC
  - Audio OS
    - Volumio
    - PiMusicBox

Raspberry Pi

Operating System setup on Raspberry Pi

- Preinstalled NOOBS OS
- OS installation
- First boot

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Topic: Smart and Connected Cities

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Smart and Connected Cities

- **An IoT Strategy for Smarter Cities**
- **Smart City IoT Architecture**
- **Smart City Security Architecture**
- **Smart City Use-Case Examples**

Smart and Connected Cities: An IoT Strategy for Smarter Cities

Recent Cisco study, expects IoT to have the following economic impact over a 10-year period:

- **Smart buildings**
  - Smart buildings have the potential to lower operating costs by reducing energy consumption through the efficient integration of heating, ventilation, and air-conditioning (HVAC) and other building infrastructure systems.
- **Gas monitoring**
  - Monitoring gas could reduce meter-reading costs and increasing the accuracy of readings for citizens and municipal utility agencies. In cases of sudden consumption increase, a timely alert could lead to emergency response teams being dispatched sooner, thus increasing the safety of the urban environment.
- **Smart parking**
  - Smart parking could provide real-time visibility into parking space availability across a city. Residents can identify and reserve the closest available space, traffic wardens can identify noncompliant usage, and municipalities can introduce demand-based pricing.

Smart and Connected Cities: An IoT Strategy for Smarter Cities

- **Water management**
    - Smart water management could connect household water meters over an IP network to provide remote usage and status information with features such as real-time consumption visibility and leak detection. Smart meters can be used to coordinate and automate private and public lawn watering
- **Road pricing**
    - Cities could implement automatic payments as vehicles enter busy city zones while improving overall traffic conditions. Real-time traffic condition data is very valuable and actionable information that can also be used to proactively reroute public transportation services or private users.
- To maximize the return on investment (ROI) on their energy and environmental investments, smart cities can employ strategies that combine water management, smart grid, waste management, particulate monitoring, and gas monitoring.
- A smart city can use these technological advances to improve its livability index, which can help attract and retain talent amid increasingly competitive labor markets.

Smart and Connected Cities: An IoT Strategy for Smarter Cities

- **Global Vs Siloed Strategies**

  The main obstacle in implementing smart solutions in today's traditional infrastructure is the complexity of how cities are operated, financed, regulated, and planned.

  The independent investment model results in the following problems:

  - Isolation of infrastructure and IT resources
  - No sharing of intelligence and information, such as video feeds and data from sensors.
  - Waste and duplication in investment and effort
  - Difficulty scaling infrastructure management

  This fragmented approach is not scalable, efficient, or economically viable, and it does not benefit from cross-functional sharing of data and services.

  Each smart city needs a tailored and structured computing model that allows distributed processing of data with the level of resiliency, scale, speed, and mobility required to efficiently and effectively deliver the value that the data being generated can create when properly processed across the network.

Smart and Connected Cities: An IoT Strategy for Smarter Cities

- **Global Vs Siloed Strategies**

  Metrics about traffic can also be processed locally to regulate and synchronize traffic lights or redirect public mass transit vehicles around congestion. Global statistics and analytics about peak times and structure can be sent to the cloud to be processed at the scale of the entire city.

Smart and Connected Cities: Smart City IoT Architecture

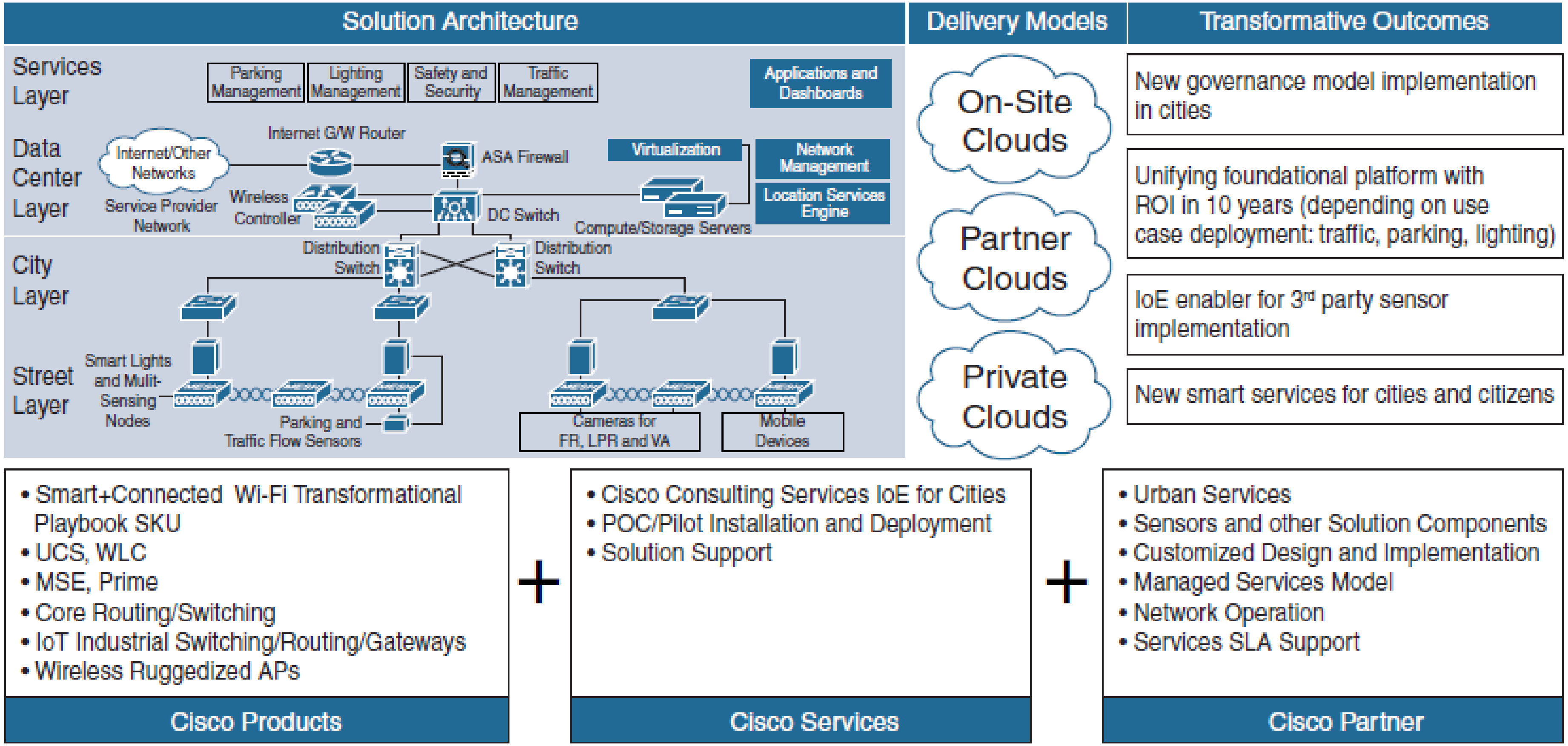

Figure 12-2 *Smart Cities Layered Architecture*

Smart and Connected Cities: Smart City IoT Architecture

- A smart city IoT infrastructure is a four-layered architecture. Data flows from devices at the street layer to the city network layer and connect to the data center layer, where the data is aggregated, normalized, and virtualized. The data center layer provides information to the services layer, which consists of the applications that provide services to the city.
- **Street Layer**
  - The street layer is composed of devices and sensors that collect data and take action based on instructions from the overall solution, as well as the networking components needed to aggregate and collect data.
  - A sensor is a data source that generates data required to understand the physical world
  - A variety of sensors are used at the street layer for a variety of smart city use cases. Example: magnetic sensor, lighting controller, Video cameras, air quality sensor.
  - One of the key aspects to consider when choosing a sensing device is its lifetime maintenance costs.
  - Another key aspect to consider when choosing the right technology for a smart city is edge analytics.
  - Event-driven systems allow the city infrastructure to be contextually intelligent so that only targeted events trigger data transfer to the cloud.
  - For sensor characteristics, storage is a key consideration that depends on the method, location, and length of time the data has to be archived

Smart and Connected Cities: Smart City IoT Architecture

- **City Layer**
  - At the city layer, network routers and switches must be deployed to match the size of city data that needs to be transported. This layer aggregates all data collected by sensors and the end-node network into a single transport network.
  - The city layer may be a simple transport layer between the edge devices and the data center or the Internet.
- **Data Center Layer**
  - Data collected from the sensors is sent to a data center, where it can be processed and correlated.
  - Based on this processing of data, meaningful information and trends can be derived, and information can be provided back.
  - The key technology in creating any comprehensive smart solution with services is the cloud. Data is stored in rented logical containers accessed through the Internet.
  - The cloud model is the chief means of delivering storage, virtualization, adaptability, and the analytics know-how that city governments require for the technological mashup and synergy of information embodied in a smart city.

Smart and Connected Cities: Smart City IoT Architecture

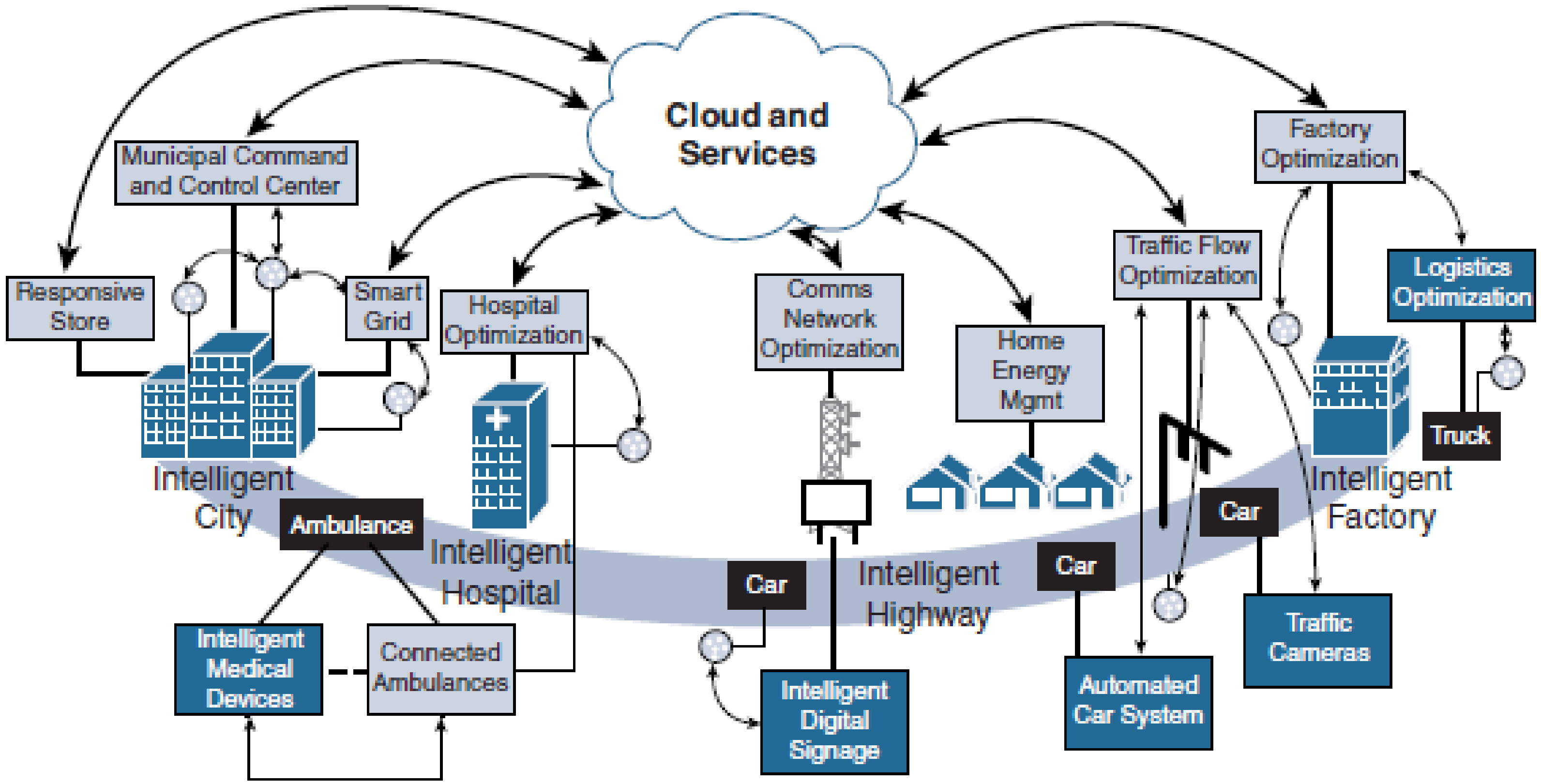

Figure 12-4 *The Role of the Cloud for Smart City Applications*

Smart and Connected Cities: Smart City IoT Architecture

- **Services Layer**
- The true value of ICT connectivity comes from the services that the measured data can provide to different users operating within a city.
- Smart city can incorporate any number of applications that can consume normalized data from a cloud-hosted platform or from fog applications.
- The entire architecture operates with compatible APIs, these applications can even enable cross-domain benefits.
- These types of cross-domain data correlations can be developed and improved by the system, inside the layered architecture, since there is a horizontal level of aggregation and normalization.

Smart and Connected Cities: Smart City Security Architecture

- Vast quantities of sensitive information are being shared at all times in a layered, real-time architecture, and cities have a duty to protect their citizens’ data from unauthorized access, collection and tampering.
- Agencies may run applications and servers on the public cloud, have limited security safeguards implemented, and use cloud-based collaboration tools without proper security. There is a need for a centralized, cloud-based, compliance-based security mechanism to address the needs of service providers and end users.
- A security architecture for smart cities must utilize security protocols to fortify each layer of the architecture and protect city data.

Smart and Connected Cities: Smart City Security Architecture

- The following are common industry elements for security on the network layer:
  - **Firewall:** A firewall is located at the edge, and it should be IPsec- and VPN-ready, and include user- and role-based access control. It should also be integrated with the architecture to give city operators remote access to the city data center.
  - **VLAN**: A VLAN provides end-to-end segmentation of data transmission, further protecting data from rogue intervention. Each service/domain has a dedicated VLAN for data transmission.
  - **Encryption:** Protecting the traffic from the sensor to the application is a common requirement to avoid data tampering and eavesdropping. In most cases, encryption starts at the sensor level. In some cases, the sensor-to-gateway link uses one type of encryption, and the gateway-to-application connection uses another encryption (for example, a VPN).

Smart and Connected Cities: Smart City Use-Case Examples

- **Connected Street Lighting**
- **Smart Parking**
- **Smart Traffic Control**
- **Connected Environment**

Smart and Connected Cities: Smart City Use-Case Examples

- **Connected Street Lighting**
- Cities commonly look for solutions to help reduce lighting expenses and at the same time improve operating efficiencies while minimizing upfront investment. The installation of a smart street lighting solution can provide significant energy savings and can also be leveraged to provide additional services.
- A human or automated operator can use a cloud application to perform automated scheduling for lights and even get light sensors to perform automated dimming or brightening, as needed.
- Lighting nodes vary widely in the industry, especially with respect to elements such as what communication protocol they use (for example, Wi-Fi, cellular, ZigBee, 802.15.4g[Wi-SUN], LoRaWAN), level of ruggedization, and on-board sensor capabilities.
- Efficiency is a key feature of smart cities, including connected lighting. For example, the amount of lighting can be reduced on highways where no cars are detected.

Smart and Connected Cities: Smart City Use-Case Examples

- **Connected Street Lighting**

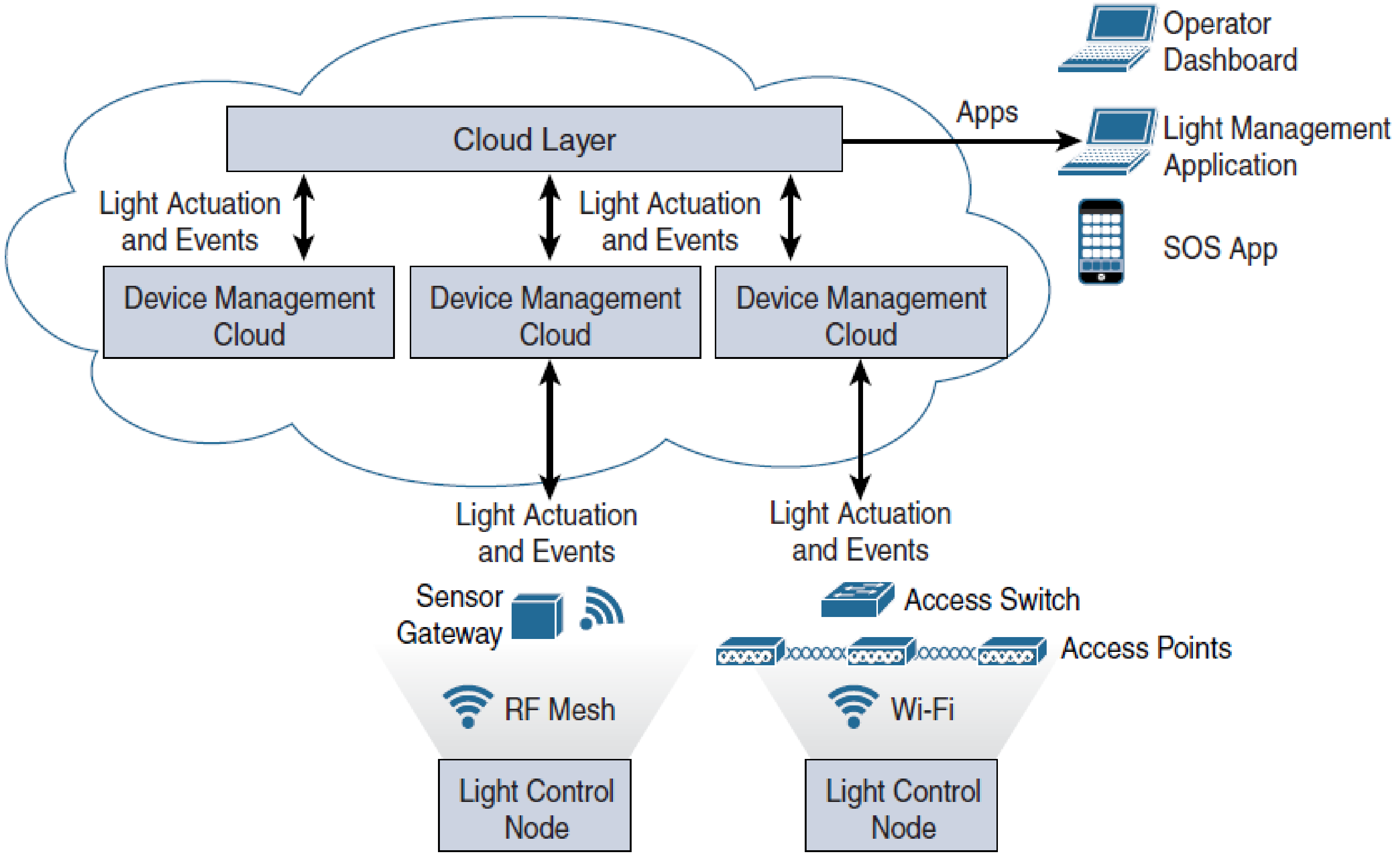

Figure 12-7 *Connected Lighting Architecture*

Smart and Connected Cities: Smart City Use-Case Examples

- **Smart Parking**
- Ineffective parking access and administration make parking in urban areas a constant struggle and affect cities in many ways.
- Smart Parking Use Cases: Added traffic congestion is one consequence of drivers looking for parking space, and it has several consequences.
  - Contributes to pollution: Tons of extra carbon emissions are released into the city's environment due to cars driving around searching for parking spots when they could be parked.
  - Causes motorist frustration: In most cities, parking spot scarcity causes drivers to lose patience and waste time, leading to road rage, inattention, and other stress factors.
  - Increases traffic incidents: Drivers searching for parking spots cause increased congestion in the streets and that, in turn, causes increased accidents and other traffic incidents.
- Revenue loss is another consequence of drivers looking unsuccessfully for parking space.
  - Cities often lose revenue: As a result of inadequate parking meter enforcement and no-parking, no-standing, and loading-zone violations, cities lose revenue.
  - Parking administration employee productivity suffers
  - Parking availability affects income: Local shops and businesses lose customers because of the decreased accessibility caused by parking space shortages.

Smart and Connected Cities: Smart City Use-Case Examples

- **Smart Parking**

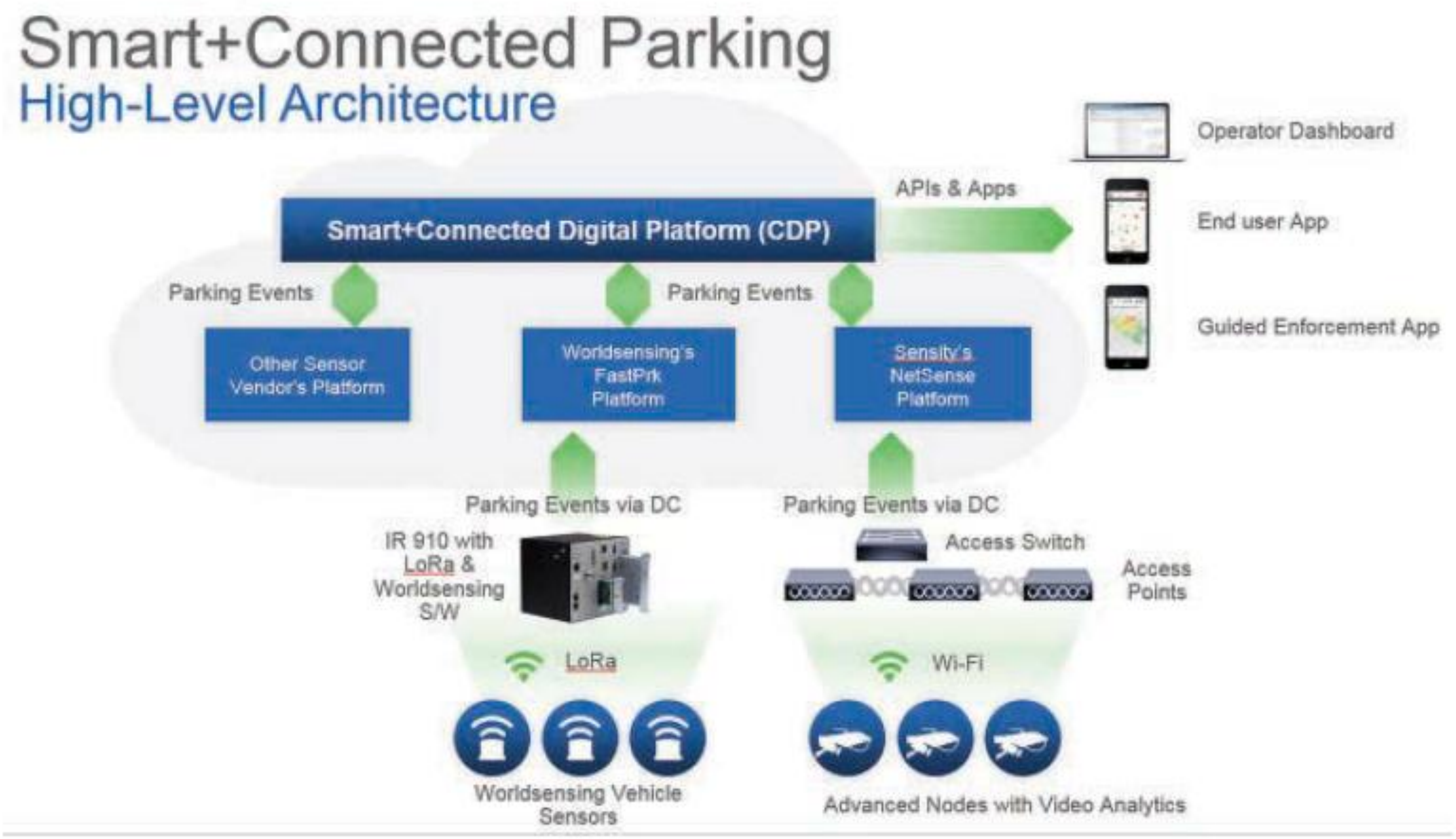

Figure 12-8 *Connected Parking Architecture*

Smart and Connected Cities: Smart City Use-Case Examples

- Three user types of smart parking are:
  - City operators
  - Parking enforcement officers
  - Citizens

Smart and Connected Cities: Smart City Use-Case Examples

- **Smart Traffic Control**

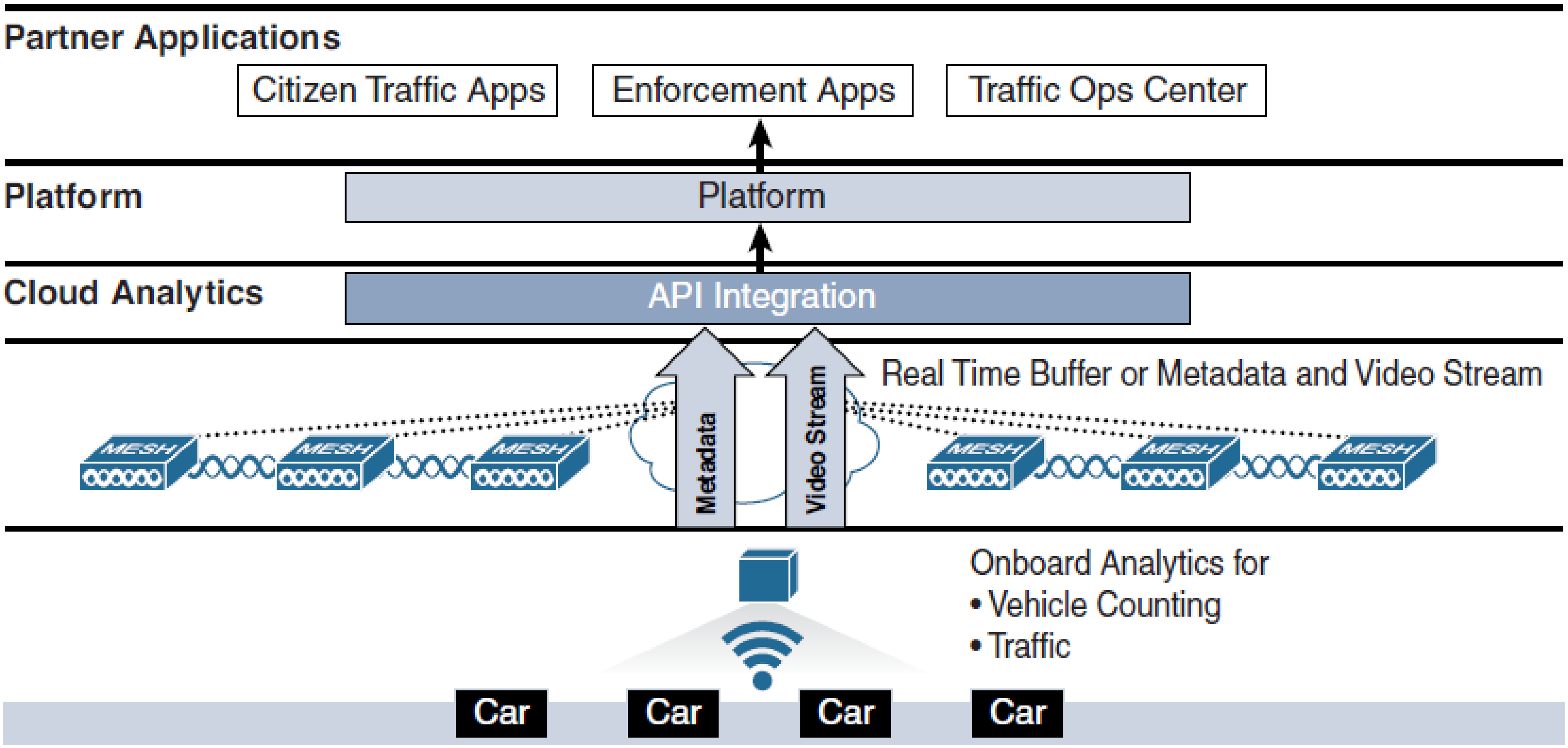

Figure 12-9 *Smart City Traffic Architecture*

Smart and Connected Cities: Smart City Use-Case Examples

- **Smart Traffic Control**
- A smart city traffic solution would combine crowd counts, transit information, vehicle counts, and so on and send events regarding incidents on the road so that other controllers on the street could take action.
- A video analytics sensor computes traffic events based on a video feed and only pushes events through the network.
- These events go through the architectural layers and reach the applications that can drive traffic services.
- Smart Traffic Applications:
  - Traffic applications can be enabled to take immediate action with other sensors to manage traffic and to reduce pain points.
  - Information can also be shared with drivers. Countless applications leverage crowd sourcing or sensor-sourced information to provide real-time travel time estimates, suggest rerouting options to avoid congestion spots.
  - Applications of city traffic pattern recognition predict the future congestions for vehicles to reroute.

Smart and Connected Cities: Smart City Use-Case Examples

- **Connected Environment:**
- Most large cities monitor their air quality. These stations are highly accurate in their measurements but also highly limited in their range, and a city is likely to have many blind spots in coverage.
- To fully address the air quality issues in the short term and the long term, a smart city would need to understand air quality on a hyper-localized, real-time, distributed basis at any given moment.
- Smart cities need to invest in connected environment due to following needs:
  - Open-data platforms that provide current air quality measurements from existing air quality monitoring stations.
  - Sensors that provide similar accuracy to the air quality stations but are available at much lower prices.
  - Actionable insights and triggers to improve air quality through cross-domain actions.
  - Visualization of environmental data for consumers and maintenance of historical air quality data records to track emissions over time

Smart and Connected Cities: Smart City Use-Case Examples

- **Connected Environment:**