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**KENNESAW STATE**  
UNIVERSITY

**Module 11:**  
**Cloud Integration with  
physical systems**  
**Sensors Data Collection  
and Cloud  
Communication**

**Dr. Maria Valero**

# Agenda

- Sensors and Sensor Types
- Features of Sensors
- Sensors in ubiquitous environments
- Object Sensors
- Data from devices
- Cloud for gathering sensor data
  - Example InfluxDB
  - Example Grafana

# Sensors

- **Sensor**

- A device that **measures** a physical quantity and **converts** it into a signal which can be read by an observer or by an instrument

- **Sensor sensitivity**

- How much the sensor's output changes when the measured quantity changes



# Sensors Types

- **Thermal:**
  - Temperature/heat sensors
- **Electromagnetic:**
  - Electrical resistance/voltage/power sensors, magnetism sensors, metal detectors, RADAR
- **Mechanical:**
  - Acceleration, position, pressure, switch, liquid sensors
- **Chemical:**
  - Odor (smell) sensor, oxygen sensors
- **Optical radiation:**
  - Light sensors, infra-red sensor, proximity sensor
- **Acoustic: Sound sensors**
- **Motion sensors:**
  - Radar gun, speedometer, tachometer, odometer
- **Orientation sensors: Gyroscope**

# Features of Sensors (1)

- **Light Sensors**

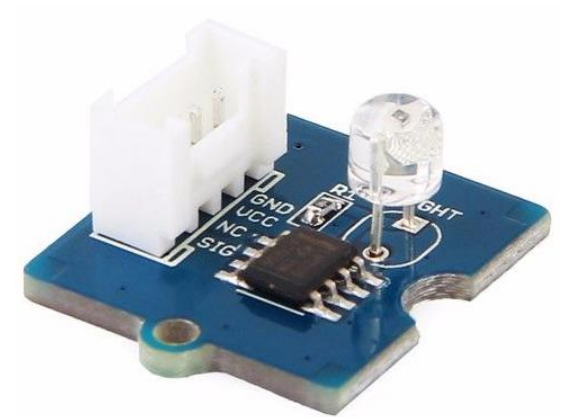
- Detecting light intensity, density, reflection, color temperature, type of light
- Rich information, very low cost

- **C-MOS Camera**

- Visual information about the environment
- Processing power and storage needs are often large
- Users feel uncomfortable

- **Location sensor**

- GPS(Global Positioning System) is mostly used
- Coarse location information
  - Cellular network infrastructures: Global System for Mobile Communications (GSM)



Light sensor

# Features of Sensors (2)

- **Audio, Microphones**

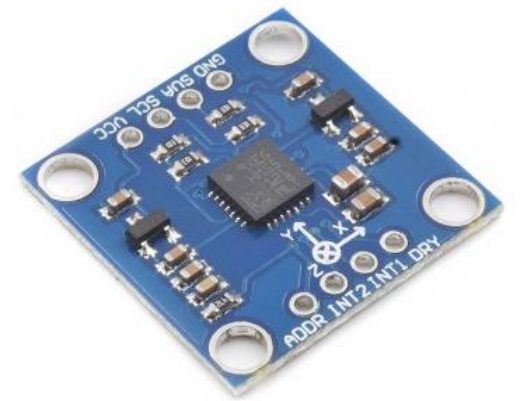
- Interesting information: Noise level, type of input, base frequency
- Using minimal processing: Less than 200 bytes of RAM
- Multiple microphones: Richer information
- Very cheap
- Can be extended up to speech recognition by using more processing power
- Ultrasonic sensors: Augment human sensory capabilities

- **Accelerometers**

- Information on the inclination, motion, acceleration of the device
- Typical: Mercury switches, angular sensors, accelerometers
- Especially interesting in examination of usage patterns

- **Touch sensor**

- Can reduce energy consumption: operative in the user's hand



Accelerometer sensor

# Features of Sensors (3)

- **Air pressure**
  - Some hints: Closing door
- **Temperature sensor**
  - Most sensors are cheap and easy to use
  - Detect body heat, arctic or desert environments
- **Passive IR sensors (Motion detector)**
  - Movement of the device itself is detected as well
- **Proximity sensors**
  - Determine a proximate distance between a physical object in the range and the device
- **Gas sensor**
  - Problem: delay in measurement, enormous energy consumption



Air Pressure Sensor

# Features of Sensors (4)

- **Biosensors**

- User awareness
- Skin resistance, blood pressure: sports and medical applications
- Emotional state of the user may be obtained

- **Magnetic field**

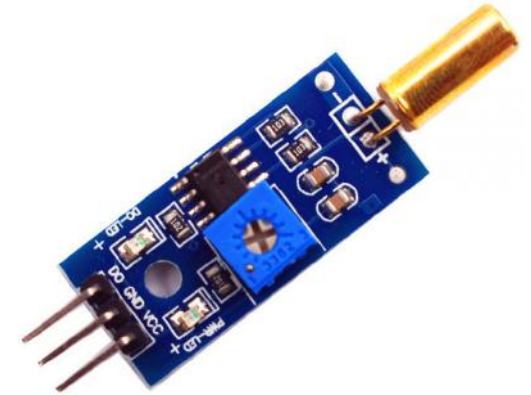
- Similar to a compass
- Direction of a device or movement can be determined
- This sensor can give false information

- **Tilt sensors**

- Determine the tilt angles of the device

- **No-power sensors**

- Metal ball switches, mercury switches, solar panels
- Extremely low power consumption



Tilt Sensor



# Sensing Environments

- Information processing has been thoroughly integrated into everyday objects and activities → Ubiquitous environments
- **Paradigm change**
  - Ordinary: a single user consciously engages a single device for a specialized purpose
  - New: engages many computational devices and systems simultaneously, in the course of ordinary activities, and may not necessarily even be aware that they are doing so
- **Related technologies**
  - Ubiquitous computing, pervasive computing, ambient intelligence
  - Haptic computing, things that think

# Sensors in Ubiquitous Environments

- **Body Sensor**

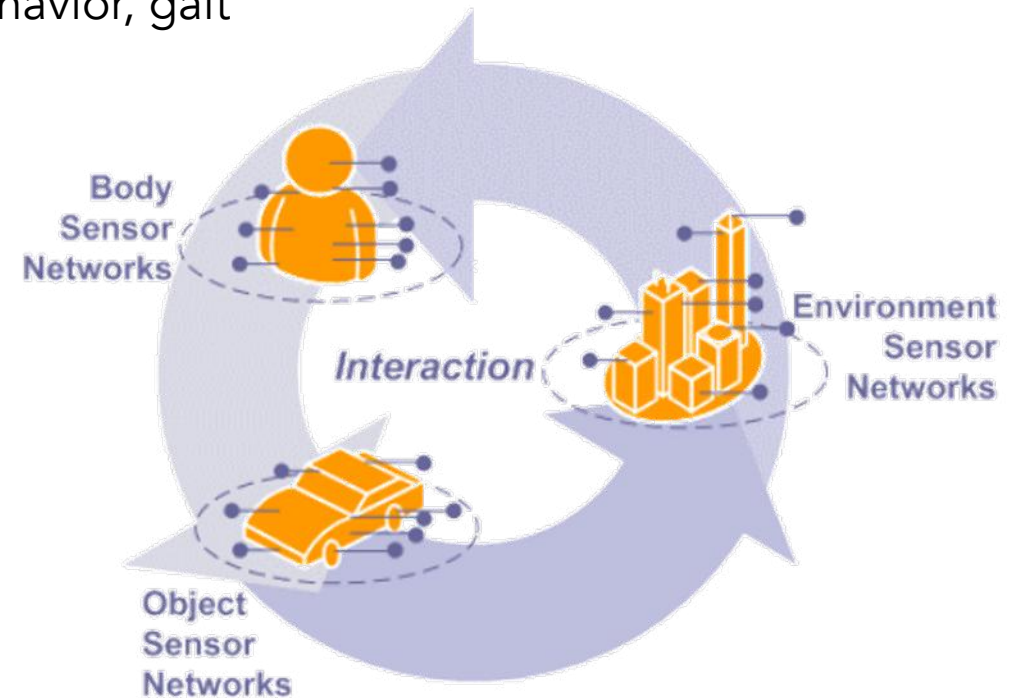
- Physiological sensor
- Biosensor: Identity, emotion, facial expression, behavior, gait
- Location sensor (GPS)

- **Environment Sensor**

- Video camera
- Light
- Noise & sound
- Temperature & humidity
- Pressure
- Movement
- Acceleration

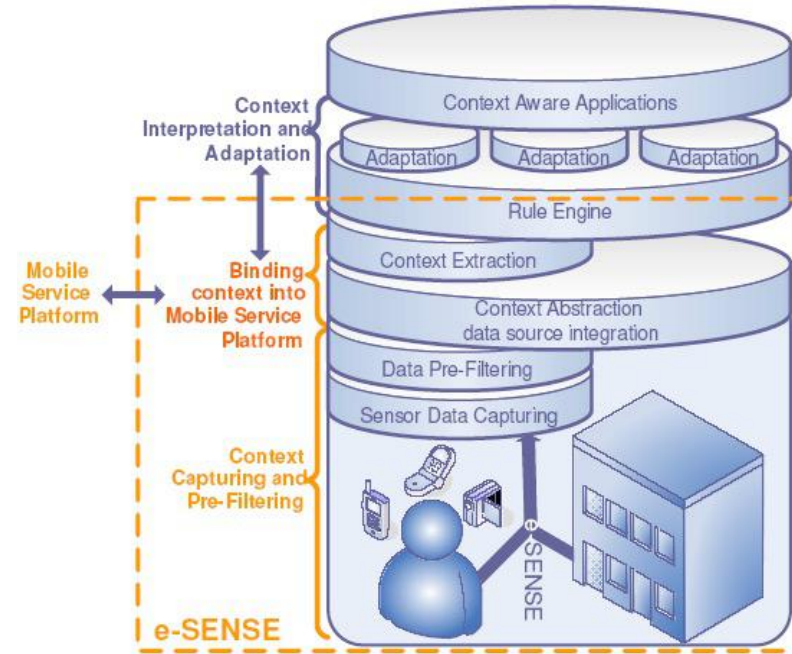
- **Object Sensor**

- Position & status of object



# Service & Applications

- Application model



## Services

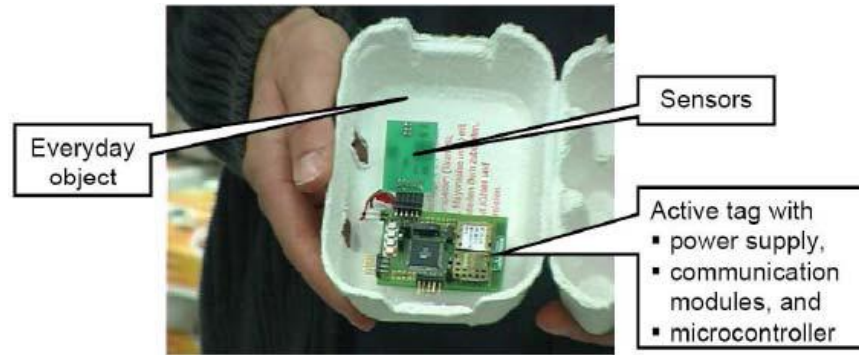
Application Space	Personal Services	Community Services	Industrial Services
Theme	Lifestyle Assistant	Wireless Healthcare	Asset Monitoring
Use Cases	1. Mood based services 2. Nutrition 3. Entertainment	4. Wireless hospital 5. Remote patient monitoring 5. Emergency coordination	7. Store of the future 8. Food processing tracking

# Sensor Data & Processing

Input Data	Sensor	Data Processing Techniques
Video	CCD CMOS	<ul style="list-style-type: none"> <li>•Compression: MPEGX, H.26X, JPEG</li> <li>•Facial detection techniques</li> <li>•Data streamining techniques</li> </ul>
Audio	Microphone	<ul style="list-style-type: none"> <li>•Compression: MPEGX, G.7XX, AAC</li> <li>•Audio data processing techniques</li> <li>•Voice recognition</li> </ul>
Position	GPS RF (Radio Frequency) system	<ul style="list-style-type: none"> <li>•Position detection</li> <li>•Map data mapping (addressing)</li> <li>•Time detection</li> </ul>
Bio	ECG, EEG, EMG, PPG, GSR Skin temperature Respiration Blood Pressure (BP)	<ul style="list-style-type: none"> <li>•Heart Rate Extraction</li> <li>•Stress Level</li> <li>•Emotion Estimation</li> <li>•Alpha Wave Detection</li> <li>•Electrohystereogram, body temperature extraction</li> <li>•Health Monitoring</li> <li>•Noninvasive BP estimation</li> </ul>
Environment	Light, Humidity, Temperature, Ultraviolet sensor	<ul style="list-style-type: none"> <li>•Noise reduction</li> <li>•Awareness Environment</li> </ul>
Movement		<ul style="list-style-type: none"> <li>•Falling detection</li> <li>•Gesture recognition (walking, running, ...)</li> <li>•Human interface</li> </ul>

- Data mining techniques
- Data searching techniques
- Feature extraction techniques

# Object Sensors

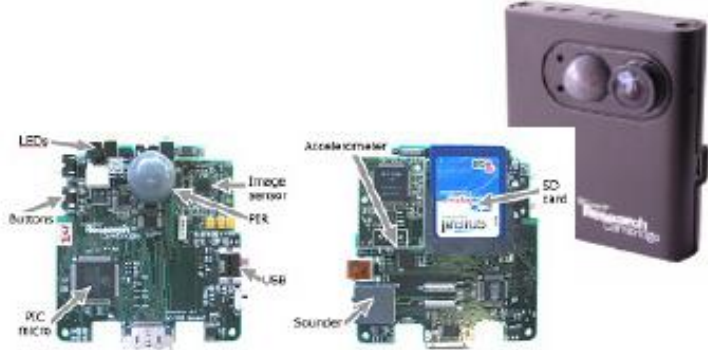


Intelligent object of Swiss ETH



Smart Bag - MIT bYOB Project

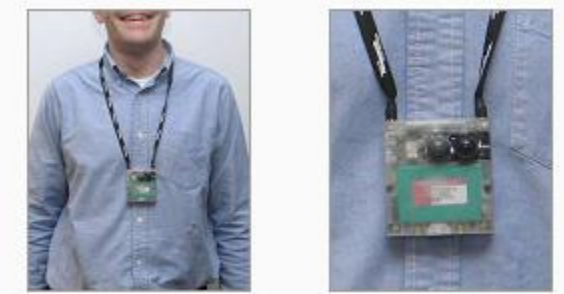
# Body Sensors (1)



Microsoft's SenseCam



Microsoft's Spot Watch



Body Media's ArmBand

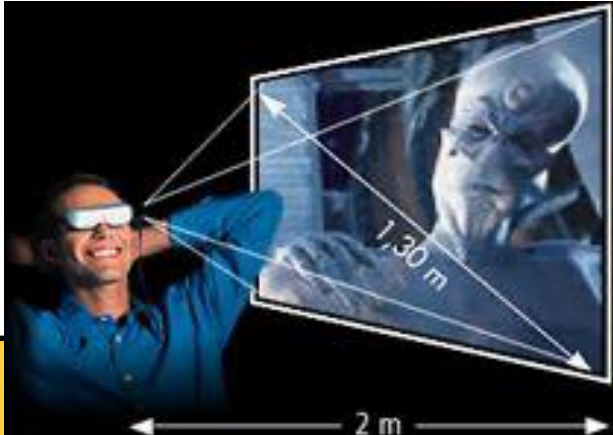


Adias' Intelligent Shoes

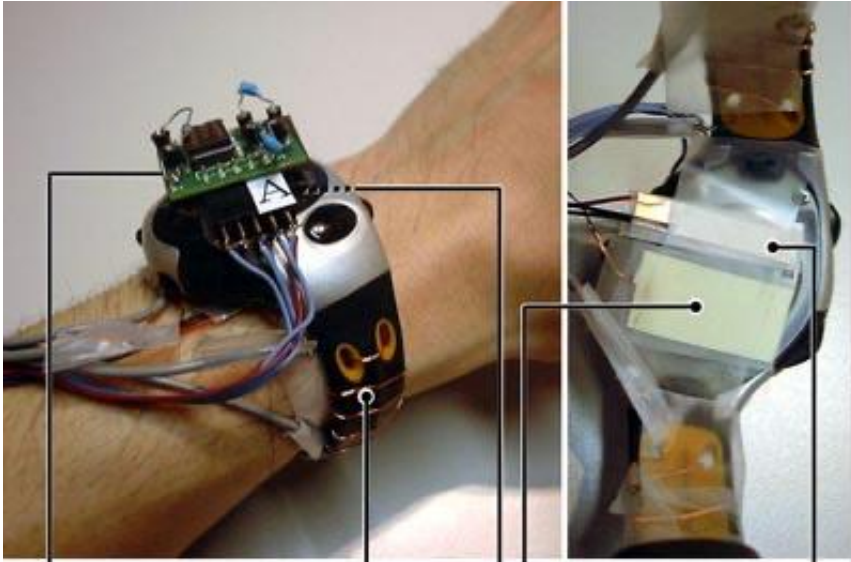
# Body Sensors (2)



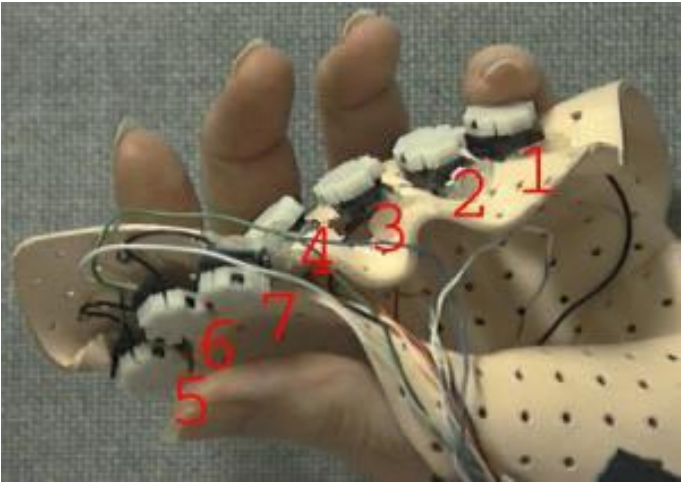
Olympus Optical Co., Ltd. is pleased to announce its new wearable user interface technologies. Employing gestures and other hand movements for input, the system is an ideal match for new wearable PCs.

A photograph of a hand wearing several small, green, ring-like sensors on the fingers. A larger, green, rectangular device is attached to the wrist, connected to the rings by thin wires. The hand is shown in a slightly flexed position.

# Body Sensors (3)



Acceleration Sensor  
Receiver Electrodes  
Transmitter Electrode  
Piezo Actuator



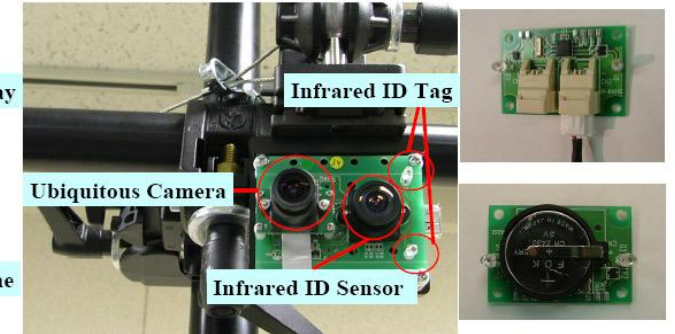
<http://www.redwoodhouse.com/wearable/index.html>  
<http://wearables.cs.bris.ac.uk/public/wearables/esleeve.htm>  
<http://www.ices.cmu.edu/design/streetware/>



# Integrated Sensors

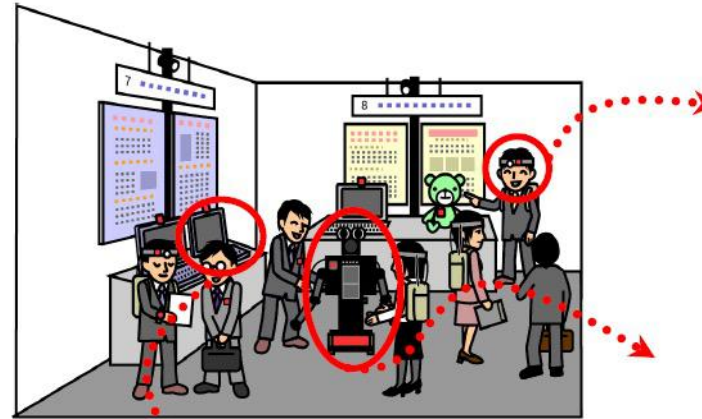


Headset



Ubiquitous Sensors

ID tag units



Personal Guidance System



Video Summary System



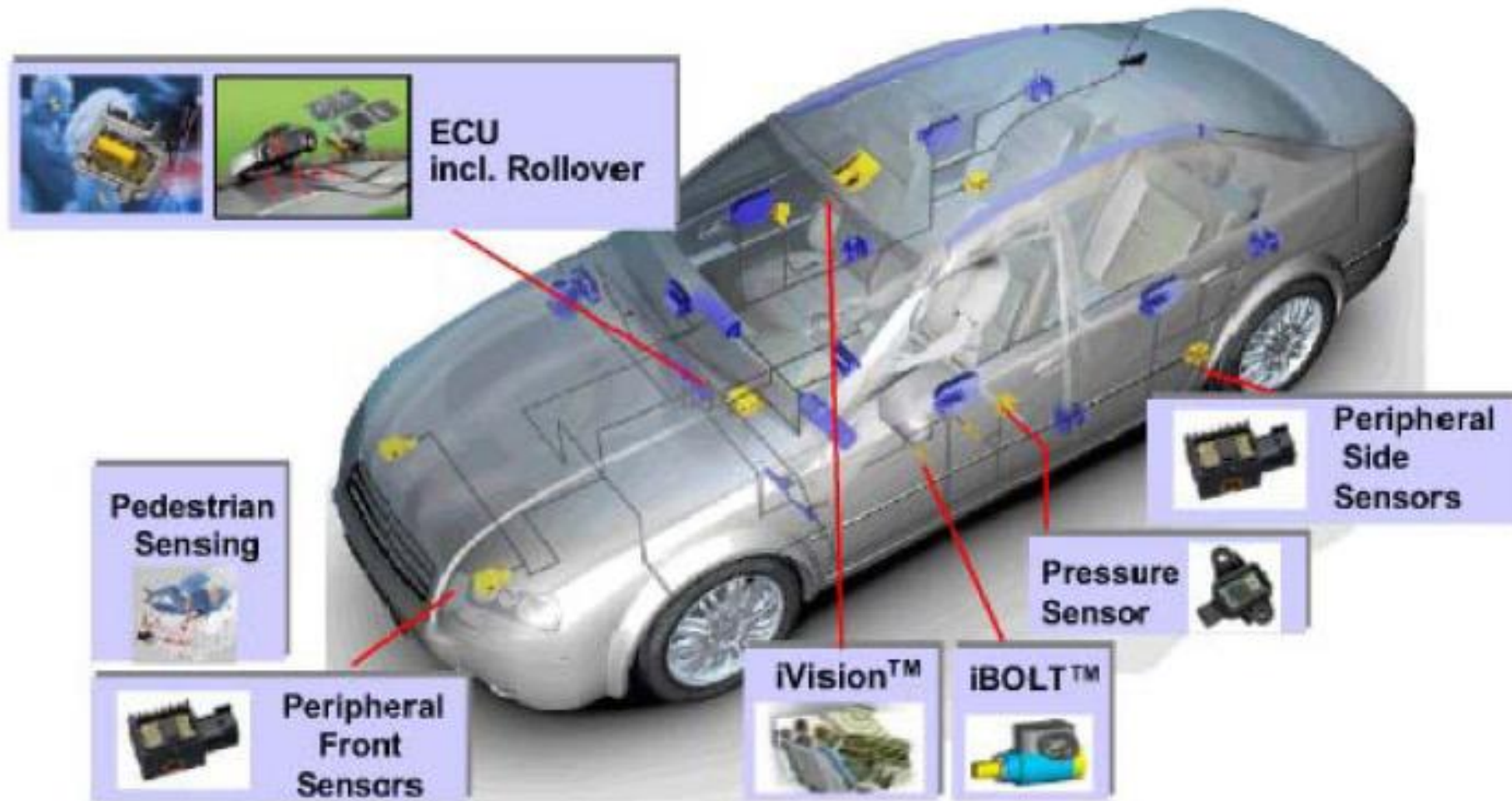
Communication Robot

# Sensor for smart cars



# Sensor Model for Smart Car

## Occupant Safety Systems Portfolio



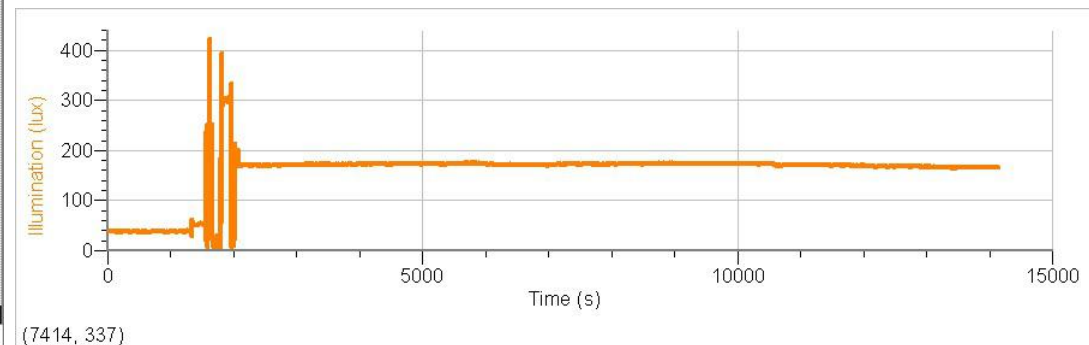
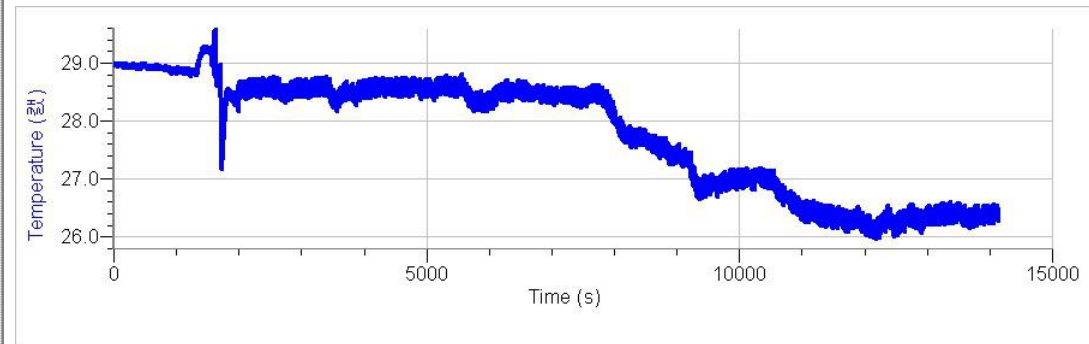
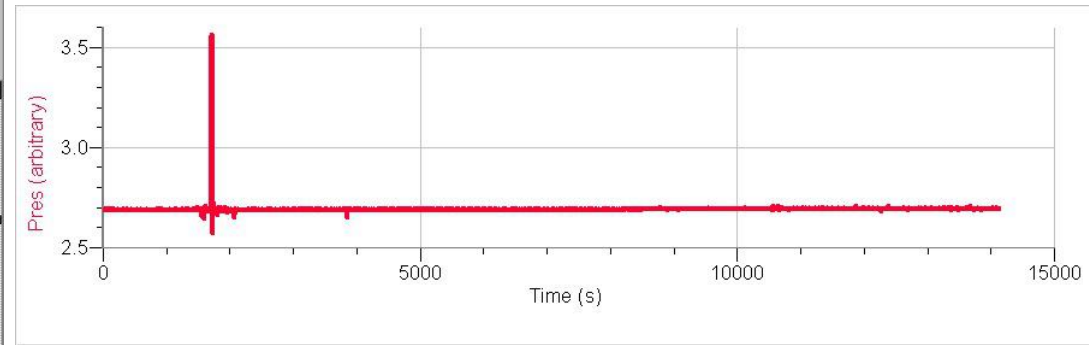
# Data from Devices (1)

- A great variety of sensors produce stream data.
- Stream data is composed for 1D data that typically is in the form value and timestamp.
- For example, a temperature sensor captures temperature during a specific timestamp. See example

Timestamp	Temperature
1/11/2022 10:12:00	73
1/11/2022 10:12:01	75
1/11/2022 10:12:02	78
....	....

# Data from Devices (2)

	Latest				
	Time (s)	Pres (arbitrary)	Offset (arbitrary)	Temperature (°C)	Illumination (lux)
1714	1714	2.690	-0.002	28.7	9.4
1715	1715	2.684	-0.008	28.7	10.0
1716	1716	3.563	0.871	28.4	10.3
1717	1717	2.695	0.003	27.8	11.1
1718	1718	2.691	-0.001	27.6	17.5
1719	1719	2.570	-0.122	27.4	14.9
1720	1720	2.596	-0.096	27.4	15.4
1721	1721	2.751	0.059	27.3	16.2
1722	1722	3.049	0.357	27.3	16.4
1723	1723	2.630	-0.062	27.2	15.4
1724	1724	2.694	0.001	27.2	15.2
1725	1725	2.631	-0.061	27.2	13.7
1726	1726	2.690	-0.002	27.2	13.9
1727	1727	2.696	0.004	27.2	14.7
1728	1728	2.689	-0.004	27.2	15.4
1729	1729	2.694	0.001	27.2	15.2
1730	1730	2.690	-0.002	27.2	14.9
1731	1731	2.691	-0.001	27.2	14.1
1732	1732	2.689	-0.004	27.2	13.9
1733	1733	2.685	-0.007	27.3	13.9
1734	1734	2.687	-0.005	27.3	14.5
1735	1735	2.691	-0.001	27.3	15.2
1736	1736	2.687	-0.005	27.4	11.7
1737	1737	2.690	-0.002	27.4	9.0
1738	1738	2.686	-0.006	27.4	6.6
1739	1739	2.689	-0.004	27.4	32.0
1740	1740	2.680	-0.012	27.4	25.8
1741	1741	2.684	-0.008	27.5	29.5
1742	1742	2.687	-0.005	27.5	29.9
1743	1743	2.685	-0.007	27.5	27.8
1744	1744	2.690	-0.002	27.6	27.6
1745	1745	2.686	-0.006	27.6	28.8
1746	1746	2.687	-0.005	27.6	31.0
1747					



(7414, 337)

# Cloud for gathering sensor data

- Data analysis and visualization of data sensors can be done in multiple Cloud Platforms.



- Cloud technologies have already integrated IoT hubs to retrieve information from devices
- We are going to study other Cloud Databases and Visualization tools to gather and visualize data



# InfluxDB + Grafana

- InfluxDB is a time-series database
- Grafana is a metrics dashboard
  
- **Benefits**
  - Both are very easy to install
    - Nowadays there are online tools (no need for installation)
  - Easy to put data into InfluxDB
  - Easy to make nice plots in Grafana
  - FREE

# InfluxDB (1)

- Time series database
- Written in Go – no external dependencies
- SQL-like query language (InfluxSQL)
- Distributed (or not)
  - Can be run as a single node
  - Can be run as a cluster for redundancy & performance
- Data can be written into InfluxDB in many ways
  - REST
  - API (e.g. Python)
  - File
  - Graphite, collectd



# InfluxDB (2)

- Data organized by time series, grouped together into databases
- Time series can have zero to many points
- Each point consists of
  - Time
  - A measurement
    - E.g. cpu\_load
  - At least one key-value field
    - E.g. value = 5
  - Zero to many tags containing metadata
    - E.g. host=lcg423

# InfluxDB (3)

- Points written into InfluxDB using the line protocol format
  - `<measurement>[,<tag-key>=<tag-value>...]<field-key>=<field-value>[,<field2-key>=<field2-value>...][timestamp]`
- Example for an FTS3 server
  - `Active_transfers,host=logfts01,vo=atlas value=21`
- Can write multiple points in batches to get better performance
  - This is recommended
  - Example with 2000 points
    - Sequentially : 129.7s
    - In a batch: 0.16s

# InfluxDB – Example Query

```
> select value,vo from active_transfers where host='lcgfts01' and time >
now() - 3m
```

```
name: active_transfers
```

```
-----
```

time	value	vo
2016-01-14T21:25:02.143556502Z	100	cms
2016-01-14T21:25:02.143556502Z	7	cms/becms
2016-01-14T21:26:01.256006762Z	102	cms
2016-01-14T21:26:01.256006762Z	8	cms/becms
2016-01-14T21:27:01.455021342Z	97	cms
2016-01-14T21:27:01.455021342Z	7	cms/becms
2016-01-14T21:27:01.455021342Z	1	cms/dcms

# Sending metrics to InfluxDB

- Python scripts, using python-requests
- Read InfluxDB host(s) from configuration file, for future cluster use.
- Alternatively, can just use curl

```
curl -s -X POST "http://<hostname>:8086/write?db=test" -u user:passwd --data-binary "data,host=srv1 value=5"
```

# Grafana – Data Sources

The screenshot displays the Grafana interface for managing data sources. The left sidebar contains navigation options: Dashboards, Data Sources, and user management (root, STFC, Grafana admin, Sign out). The main content area is titled 'Data sources' and shows a table of existing sources.

Name	Uri	Refresh	Delete
ARC	http://influxdb01.gridpp.rl.ac.uk:8086	Refresh	✖
cloud	http://influxdb01.gridpp.rl.ac.uk:8086	Refresh	✖
docker registry	http://influxdb01.gridpp.rl.ac.uk:8086	Refresh	✖
fts3	http://influxdb01.gridpp.rl.ac.uk:8086	Refresh	✖
galera	http://influxdb01.gridpp.rl.ac.uk:8086	Refresh	✖
htcondor	http://influxdb01.gridpp.rl.ac.uk:8086	Refresh	✖
influxdb	http://influxdb01.gridpp.rl.ac.uk:8086	Refresh	✖

# Grafana – Adding a Database



## Grafana – adding a database

The screenshot shows the Grafana interface for editing a data source. The breadcrumb navigation is 'Data sources > Overview > Add new > Edit'. The left sidebar shows 'Dashboards' and 'Data Sources' sections, with 'Data Sources' selected. The user is logged in as 'root'. The main content area is titled 'Edit data source' and contains the following fields:

Name	galera	Default	<input type="checkbox"/>
Type	InfluxDB 0.9.x		

**Http settings**

Url	http://influxdb01.gridpp.rl.ac.uk:8086	Access	<input type="checkbox"/> proxy
Http Auth	Basic Auth <input type="checkbox"/>	With Credentials	<input type="checkbox"/>

**InfluxDB Details**

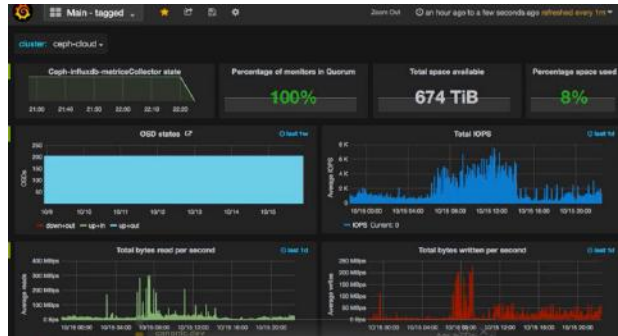
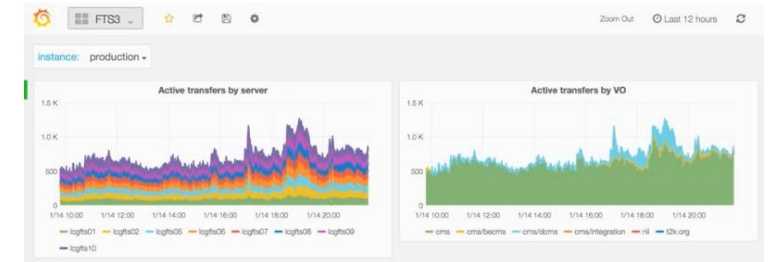
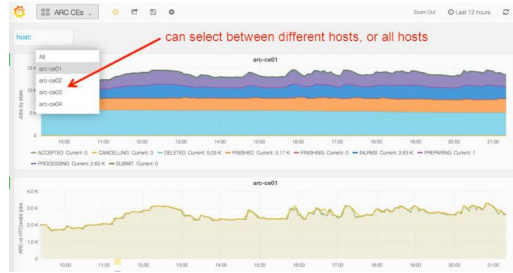
Database	galera		
User	reader	Password	.....

# Grafana – Making a plot

The image shows a Grafana dashboard for monitoring 'Batch system' jobs. A central panel titled 'Templating' displays a stacked area chart for 'ARC CEs' showing job counts by state over time. A dropdown menu for 'host' is open, listing 'All', 'arc-ce01', 'arc-ce02', 'arc-ce03', and 'arc-ce04'. A red arrow points to the 'arc-ce01' option with the text 'can select between different hosts, or all hosts'. Below the main chart is a line chart for 'arc-ce01' showing 'ARC vs HTCondor jobs' over time. The dashboard includes a left sidebar with query editor options (FROM, SELECT, GROUP BY, ALIAS BY) and a right sidebar with navigation buttons like 'Back to dashboard' and 'Zoom Out'. The top navigation bar shows 'Batch system', 'Back to dashboard', 'Zoom Out', and 'Last 12 hours'.

## Templating

grafana.com



# Grafana – Different types of plots

