Wireless Sensor Data Processing using Cloud Services

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Internet of Things

- Interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure

- Expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications (M2M) and covers a variety of protocols, domains, and applications.

Reference: www.businessinsider.com

Reference: Wikipedia

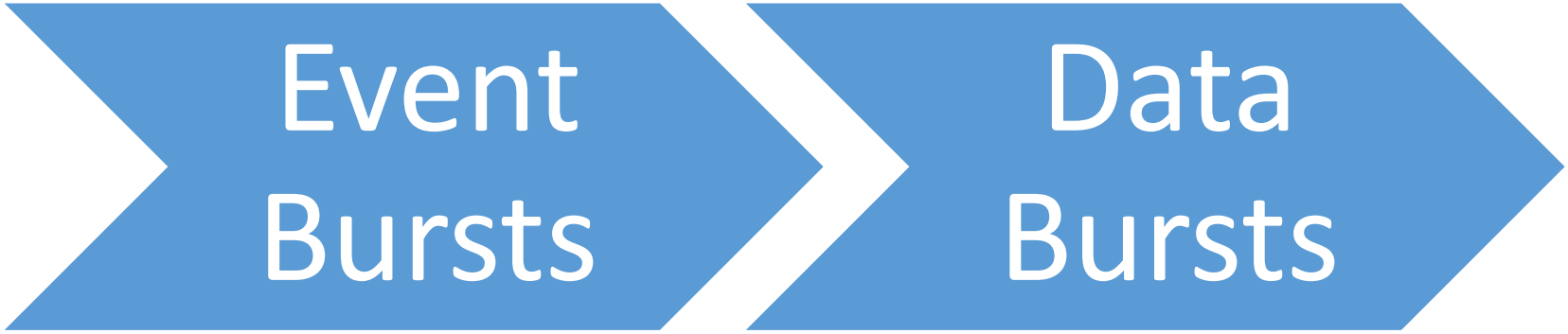
Wireless Sensor Networks

- Spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc.
- To cooperatively pass their data through the network to a main location.

Reference: Wikipedia

Reference: http://wsn.vatia.es/?lang=en

Challenges faced by conventional WSN



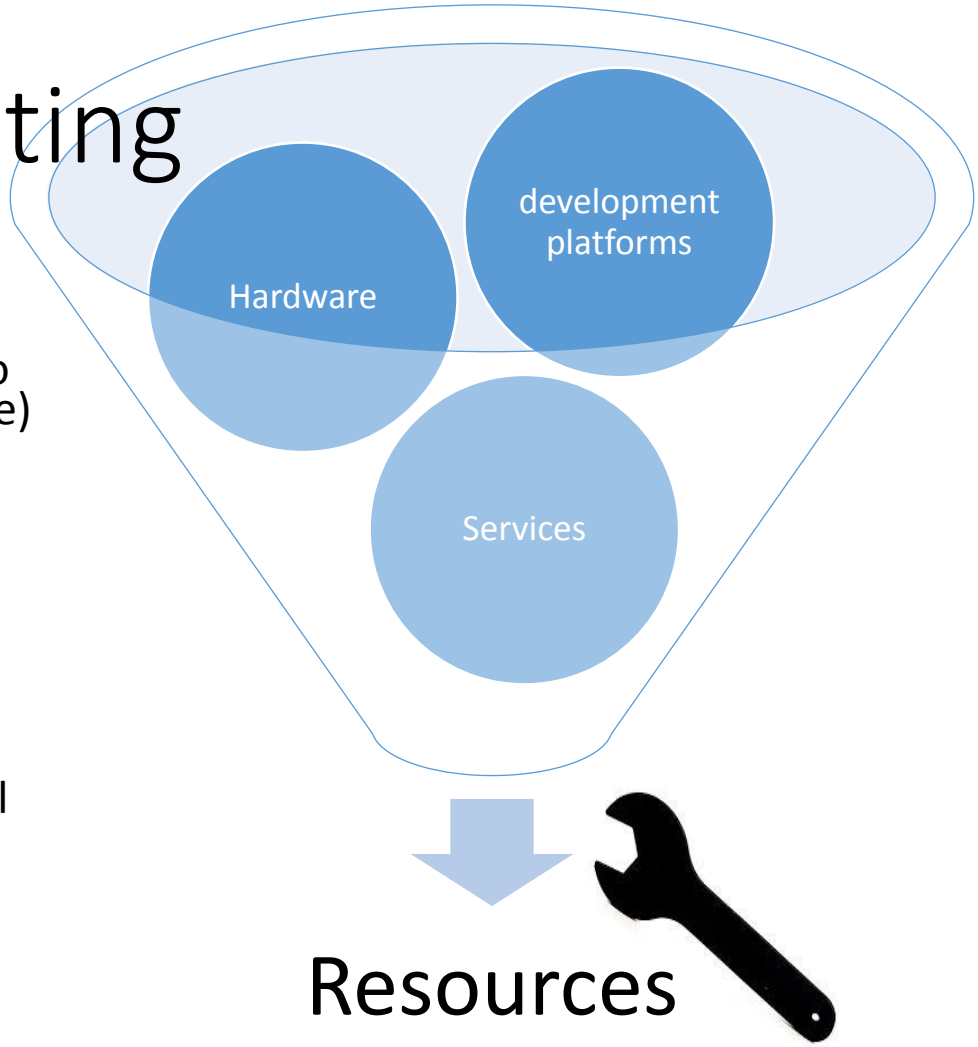
Challenges faced by conventional WSN

- Storage -
  - Size of the data to be stored
- Accessibility -
  - Privilege levels
- Reliability -
  - Lack of resilience to hardware breakdown or software crash
- Real-time processing -
  - For example, timely alerts

Cloud computing

Vaquero et al. proposed –

- A large pool of resources
- Dynamically reconfigurable to adjust to a variable load (scale)
- pay-per-use model and customized Service Level Agreements (SLAs)



Examples of resources –

Storage, Processing, Memory, Network Bandwidth, and Virtual Machines.

Examples of Cloud Computing Systems –

Dropbox, Amazon AWS, iCloud, GoGrid

Cloud Computing Illustration

Figure 1. An illustration of the Cloud Computing concept. All kinds of computing and communication devices are able to interact with the Cloud and share the same data resources. Embedded - sensor devices and microcontrollers are such way a part of the Cloud.

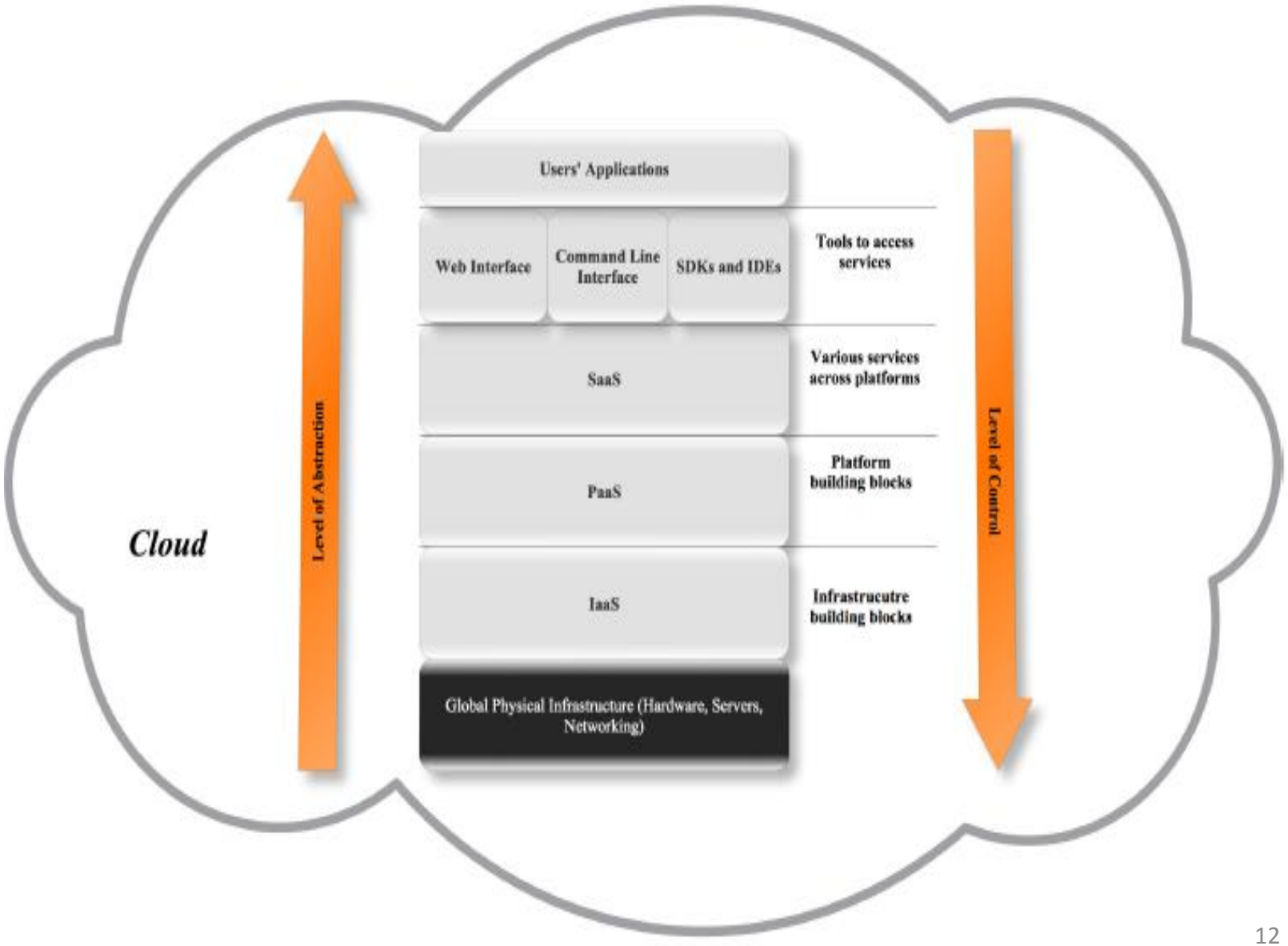
Cloud computing characteristics

- Virtualization
  Hides backend from clients
- Scalability
  Dynamic resizing of resources
- Usability
  Simple UI
- Reliability
  Resilience against data center failures
- Security
  Data protection
- Cost
  Form of pay-as-you-go

Cloud computing services categories

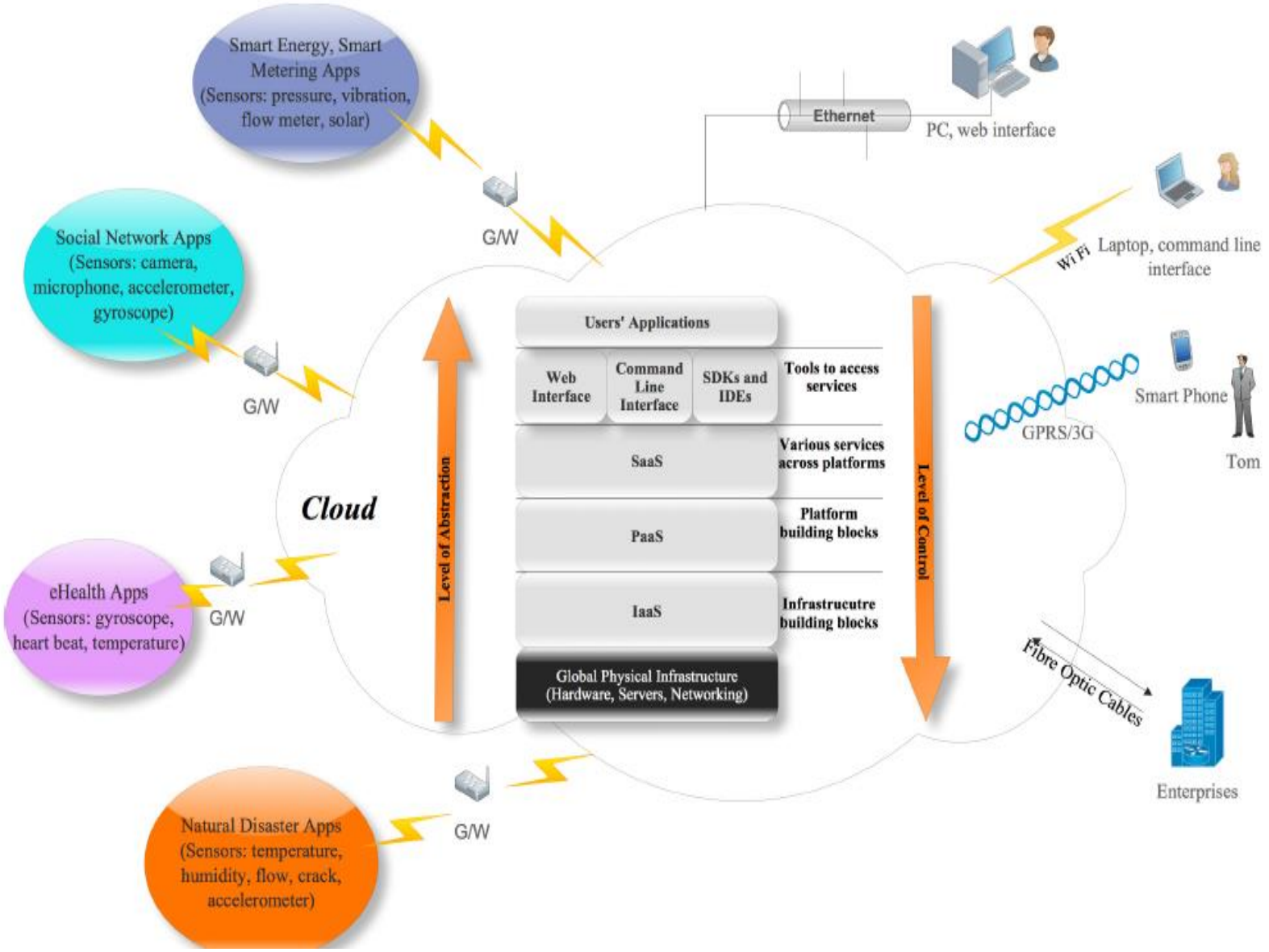
IaaS	PaaS	SaaS
• Virtualization of computing resources • Amazon Elastic Compute Cloud (EC2)	• Virtualization at the level of development environments, programming platforms and APIs for building cloud-based applications and services • Windows and various versions of Linux platforms, Java VM, Python, and .Net platforms	• Applications running on cloud instead of personal system • Google Docs programs

Service Stack of Cloud Computing



WSN on Cloud

- Cloud as the backend for sensor data storage and processing – central library with extendable capacity
- Virtually infinite capacity for data storage
- Scalable computing capability for data processing
- Agile application development tools
- Developers and users only need to spend their efforts in developing the application features
- Components such as security, scalability and shared data models have already been developed and tested with millions of users.
- Data safety – geographically distributed centers and regular data backups


Smart Energy, Smart Metering Apps (Sensors: pressure, vibration, flow meter, solar)
Social Network Apps (Sensors: camera, microphone, accelerometer, gyroscope)
eHealth Apps (Sensors: gyroscope, heart beat, temperature)
Natural Disaster Apps (Sensors: temperature, humidity, flow, crack, accelerometer)
G/W
G/W
G/W
G/W
Cloud
Level of Abstraction
Users' Applications
Web Interface
Command Line Interface
SDKs and IDEs
Tools to access services
SaaS
Various services across platforms
PaaS
Platform building blocks
IaaS
Infrastrucutre building blocks
Global Physical Infrastructure (Hardware, Servers, Networking)
Level of Control
Ethernet
PC, web interface
Wi Fi
Laptop, command line interface
GPRS/3G
Smart Phone
Tom
Fibre Optic Cables
Enterprises

Challenges faced

- Data Format and Event Processing -
  - Lack of standard representation of data coming from different types of WSNs
- Complex Event Query -
  - Different types of database requirements
- Network Bandwidth -
  - Network capacity limit
- Maintenance Dilemma -
  - Efficient allocation of computational resources (load balance) and storage
  - Data migration
- Payment for Services -
  - Regulation in order to bring a standard charge format

- Aim of the paper – Look at opportunities and challenges of applying one technology - WSN by leveraging another – Cloud computing, to tackle even more complex problems

- Synergy between WSN and Cloud Computing will offer a potential solution to various social, environmental, public problems, e.g. the global energy crisis, population ageing, and security surveillance

Managing Wearable Sensor Data through Cloud Computing

Mobile Pervasive Healthcare Technologies

- Applications –
  - Patient Monitoring
  - Emergency Response
- Challenges –
  - Data Storage and Management
  - Security and Policy
  - Interoperability and Availability of Heterogeneous resources
  - Unified and Ubiquitous Access

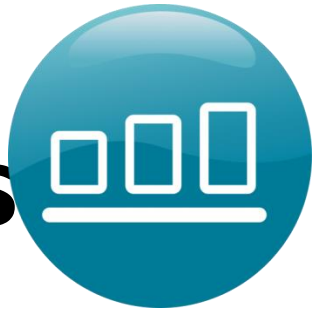
Proposed System

- Wearable textile platform based on open hardware and software that collects motion and heartbeat data
- Cloud infrastructure for monitoring and further processing

Existing Systems (1)

- First on-line database service providers that allow developers to connect sensor data to the Web.
- Manages real time sensor and environment data, graphing and monitoring and controlling remote environments.
- Free Usage and Open Source API

Existing Systems (2)

Nimbits 

- Data processing service for recording and sharing sensor data
- It is a free, social and open source
- Use JSON or XML to feed changing data points to Cloud
- Uses –
  - Generate alerts
  - Relay data to social networks
  - Connect to process control diagrams, spreadsheets, web sites and more.

Existing Systems (3)

- Open source application and API to store and retrieve data from things using HTTP over the Internet or via a Local Area Network.
- Eight data entries supported - latitude, longitude, elevation, and status, etc
- Supports JSON, XML, and CSV formats for integration
- Uses –
  - Create sensor-logging applications
  - Location tracking applications
  - A social network of things with status updates

Existing Systems (4)

- Machine-to-machine (M2M) platform-as-a-service.
- Secure, scalable, cost-effective solutions
- It makes connecting remote assets to enterprises easy, regardless of location or network.
- Provides tools to connect, manage, store and move information
- Additional Storage Options –
  - cache
  - permanent storage options

Challenges of Existing Systems

- Provides only visualization of the data
- No secure data access
- No interfaces for linkage to mobile or external applications (for further processing).
- Proprietary architectures and communication schemes
- Do not address issues of data management and interoperability issues for heterogeneous data resources

Proposed System - Overview

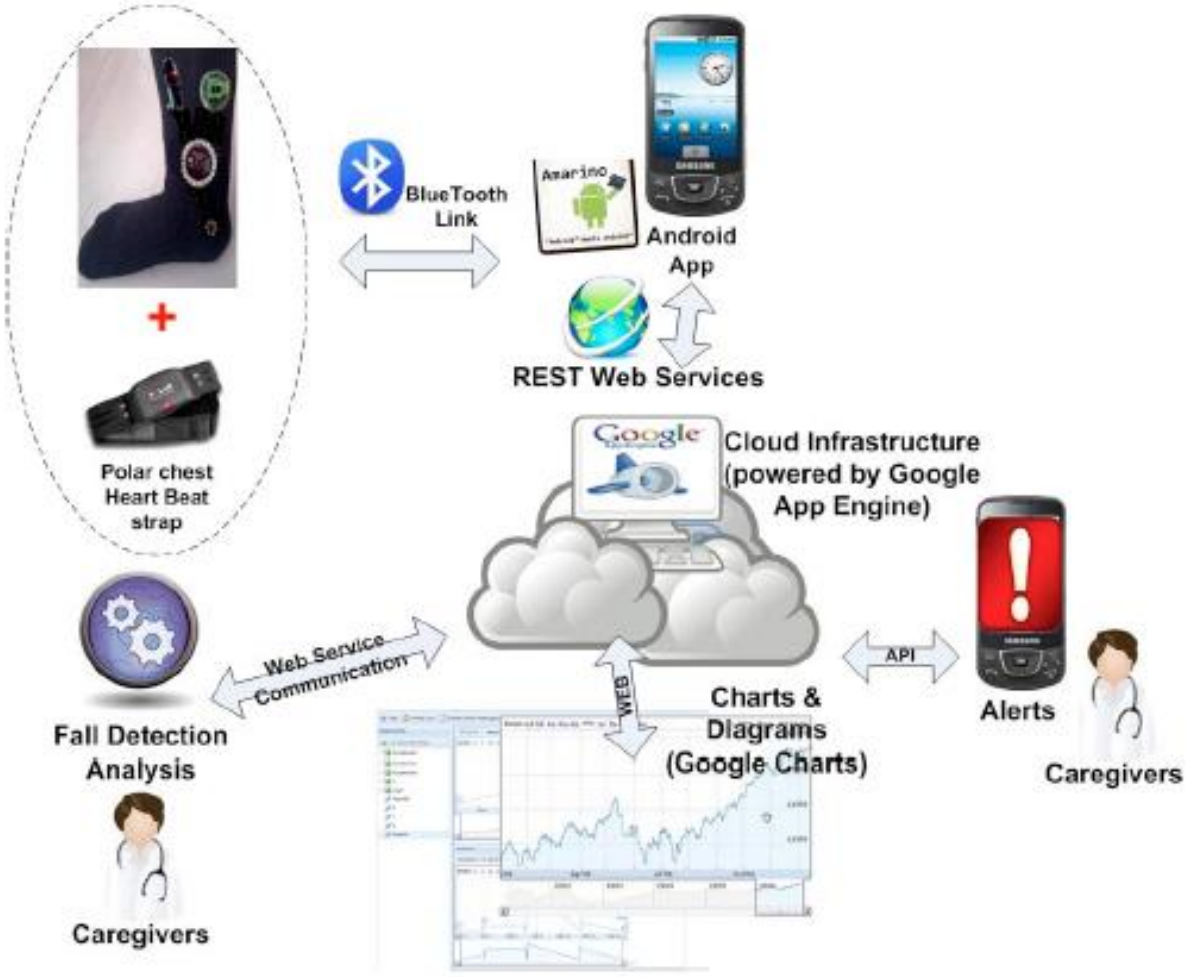


Figure 2. Illustration of the architecture, main components and interaction with users.

Components – Sensor Network

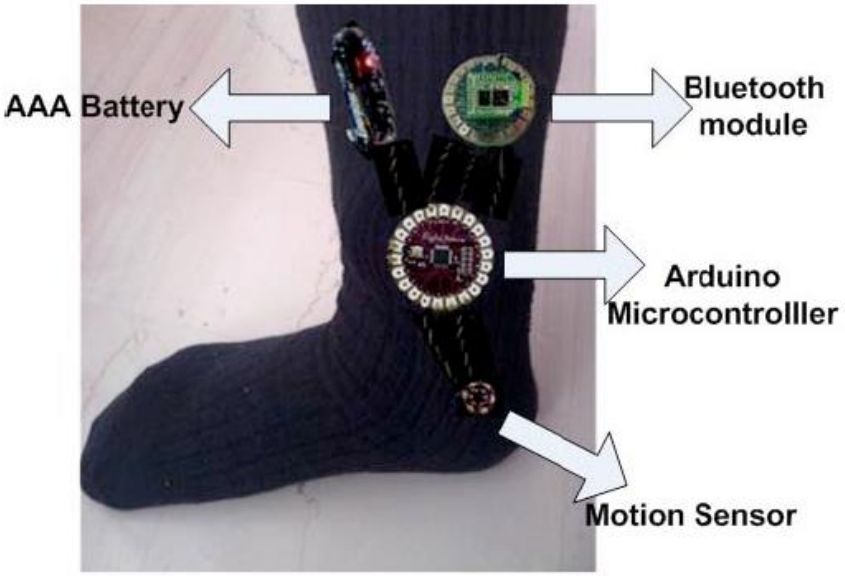
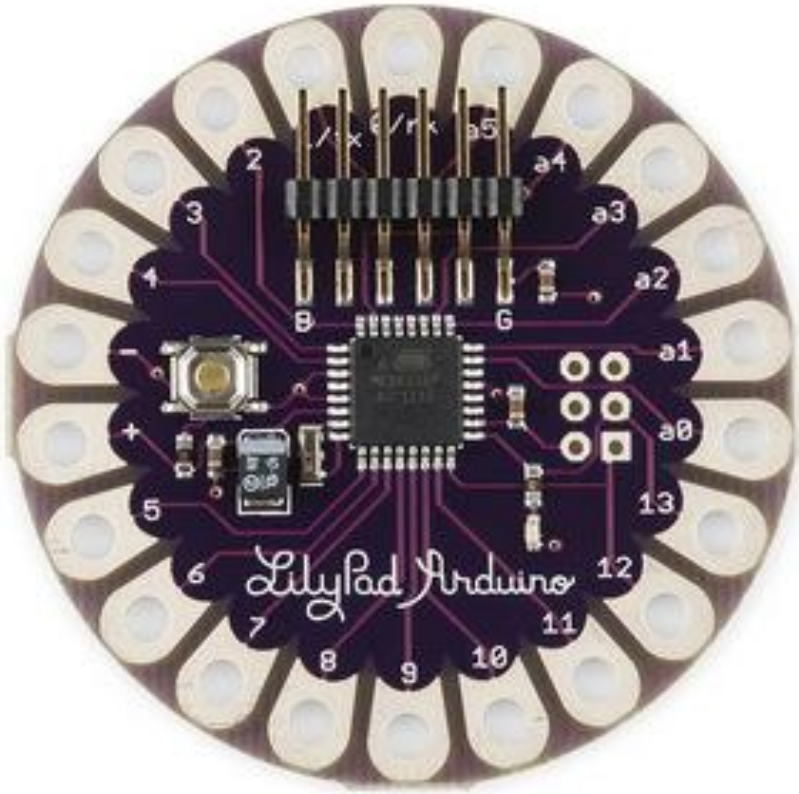


Figure 3. The CloudSensorSock and the main hardware modules as sewed on the final prototype.

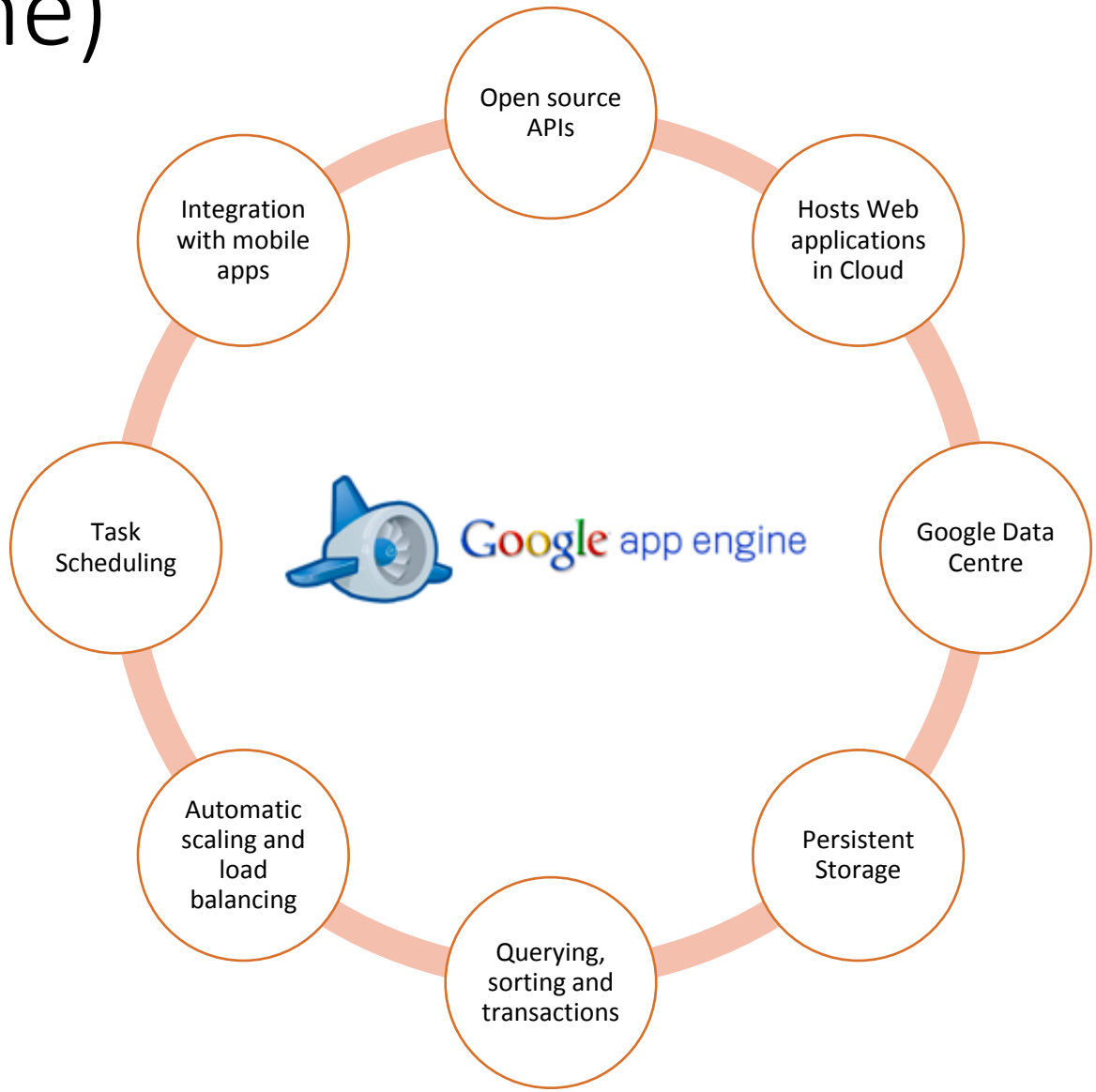
- AAA Battery
- Heartbeat Chest Strap by Polar
- Accelerometers for motion detection
- Arduino Lilypad Microcontroller for wearables and e-textiles
- Bluetooth Module

Lilipad Arduino Specifications

- The LilyPad Arduino is designed for wearables and e-textiles.
- Can be sewn to fabric and mounted power supplies, sensors and actuators with conductive thread.
- Based on theATmega168V
- Powered by USB or External Power Supply
- Washable



Components – Cloud (Google App Engine)



Drawbacks of Google App Engine

- Does not work for any *NIX compatible software
- Requires relational database
- Webservices cannot run Google App without modification
- Per day per minute quota enforce restriction on
  - Bandwidth
  - CPU usage
  - Number of Requests
  - Calls to various APIs

Initial Evaluation Results - Problems and Solutions

- Problem –
  - Very high packet loss (20-30%)
- Solution –
  - Introduce a memory buffer that collects data every 10 seconds
- Result –
  - Packet loss reduced (2-5%)

Drawbacks Observed

1. Incomplete testing and hence no details about data collected and final results expected

2. No justification of using Google App Engine for the application

Future Work

- More powerful boards can be used that can send data directly to cloud and remove the need for android

- Purchase an account with Google App Engine and conduct real benchmarking experiments

Reference

Opportunities and Challenges of Wireless Sensor Networks Using Cloud Services

Authors: Ruoshui Liu, Computer Lab, University of Cambridge, Ian J. Wassell, Computer Lab, University of Cambridge

Published in: Proceeding IoTSP '11 Proceedings of the workshop on Internet of Things and Service Platforms (Article No. 4)

Link: http://dl.acm.org/citation.cfm?id=2079357

Managing Wearable Sensor Data through Cloud Computing

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Published in: Cloud Computing Technology and Science (CloudCom), 2011 IEEE Third International Conference (Pages 440 – 445)

Link: http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6133174&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6133174

Thank You