Internet of Things based approach to Agriculture Monitoring

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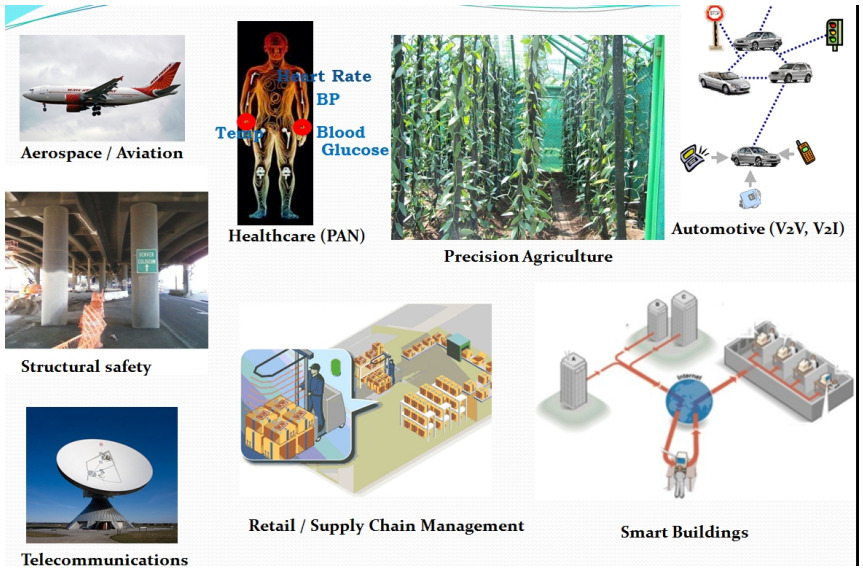
Outline

Internet of Things - Introduction

- Present day networking technologies are optimized for Human-to-Human interactions rather than Machine-to-Machine (M2M) communications
- Internet of Things (IoT) aims to extend Internet to large number of distributed devices by defining standard, interoperable communication protocols
- The major objective of Internet of Things (IoT) is to create a smart environment (smart buildings, smart health, smart transport, etc.) using enabling technologies such as sensors, embedded devices, communication protocols
- Industry estimate predicts that there would be 50 billion devices by 2020



Some key IoT enabling technologies / standards

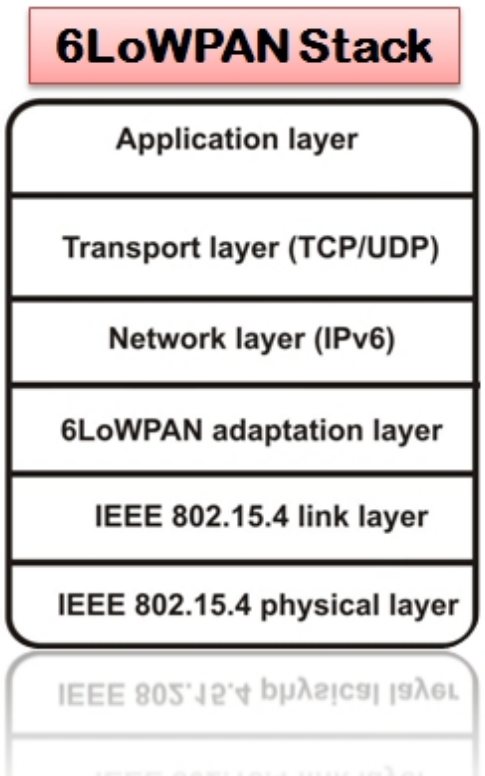
- IEEE 802.15.4 LoWPAN – specification defining the PHY and MAC layer of low power devices supporting 250 Kbps data rate, small packet size 127 bytes
- IETF 6LoWPAN (RFC 4944/RFC 6282) – enables seamless integration of LoWPAN devices with internet leveraging IPv6 large address space and appln. layer protocol reuse.
- IETF CoAP – open application layer specification for constrained nodes supporting HTTP and Web integration.
- Bluetooth SMART devices – support low energy radio operations (e.g, heart-rate monitors, blood glucose monitors) suitable for health care and fitness etc.
- RFID / NFC – tags, devices, smart phones (useful in product / object identification and gathering associated information)

6LoWPAN Overview

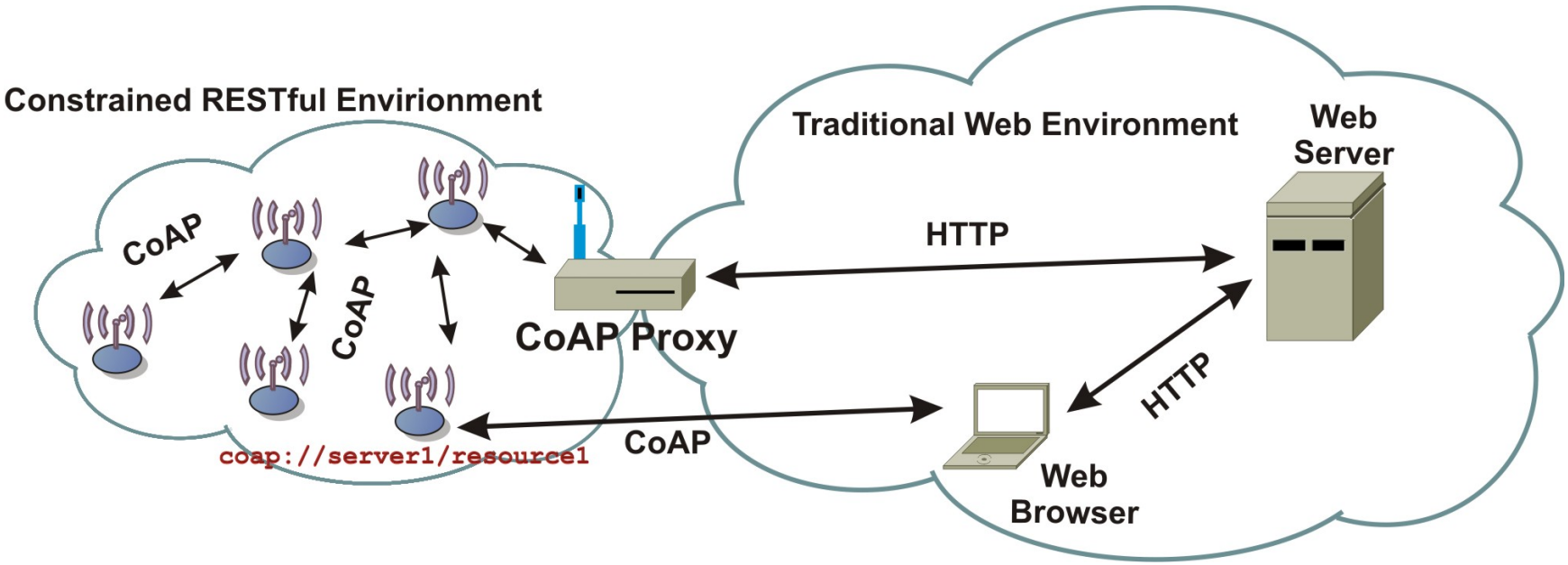
- IETF RFC 4944 Transmission of IPv6 packets over 802.15.4 LoWPAN networks
- Challenges:

	IPv6 network	**LoWPAN**
MTU	1280 bytes	127 bytes
Data rate	Mbps/ Gbps	Max 250 Kbps
Comm. distance	$>$ 100 mts	10 mts
Topology	Broadcast	Mesh / Star

- 6LoWPAN Adaptation Layer
  - Header compression
  - Fragmentation
  - Layer 2 forwarding

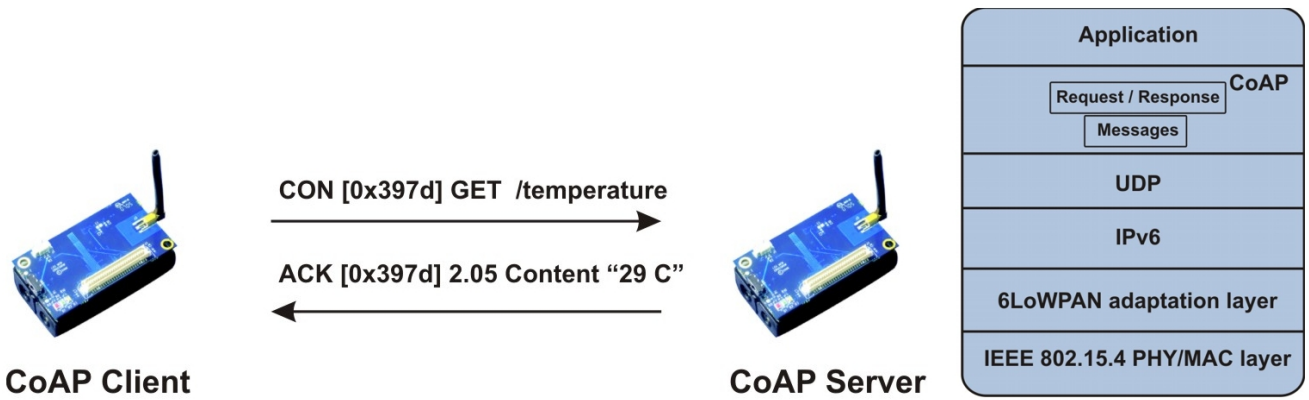


Constrained RESTful Environment (CoRE) Architecture



- CoAP is an application layer protocol (IETF draft) for resource constrained devices
- Adheres to RESTful approach for managing resources and supports mapping to HTTP for Web integration.
- CoAP resources are identified by Uniform Resource Identifiers (URI)

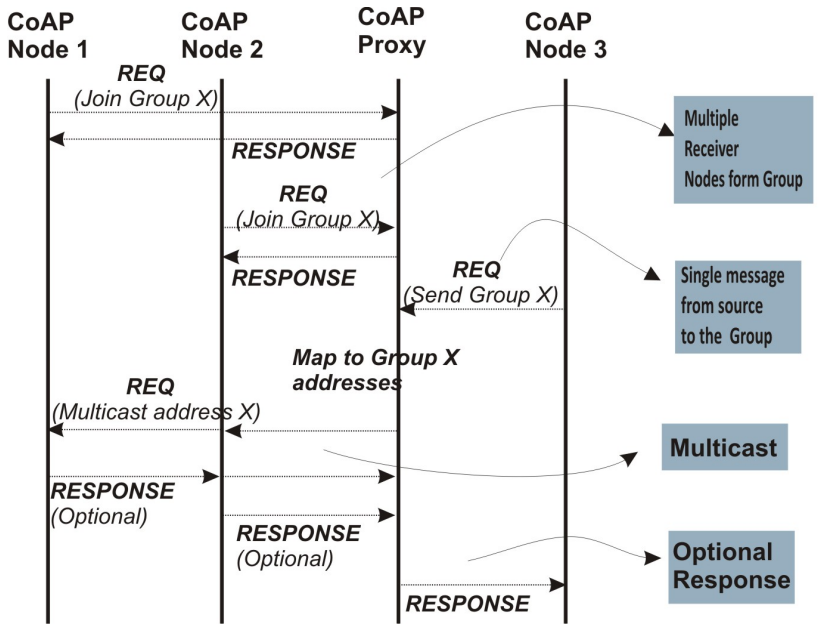
Constrained Application Protocol (CoAP)



- Asynchronous message interactions over UDP, Request/Response semantics
- CoAP messages are short - 4 bytes header followed by options (Typically, 10-20 bytes header)
- Four message types: Confirmable [CON], Non-confirmable [NON], Acknowledgments [ACK], and Reset [RST]
- Four CoAP methods: `GET`,`POST`, `PUT` and `DELETE`
- Default resource path `/.well-known/core` for built-in resource discovery

Some IETF protocols developed in IoT domain

- IP multicast based CoAP Group communication
- DTLS in Constrained Environment (DICE) – defines constrained datagram TLS with specific usecase in IoT
- 6LoWPAN adaption for various link layer technologies
  - Bluetooth low enery (BLE)
  - ITU G.9959 (ZWave)
  - DECT ultra low energy
  - low speed serial lines (RS485)

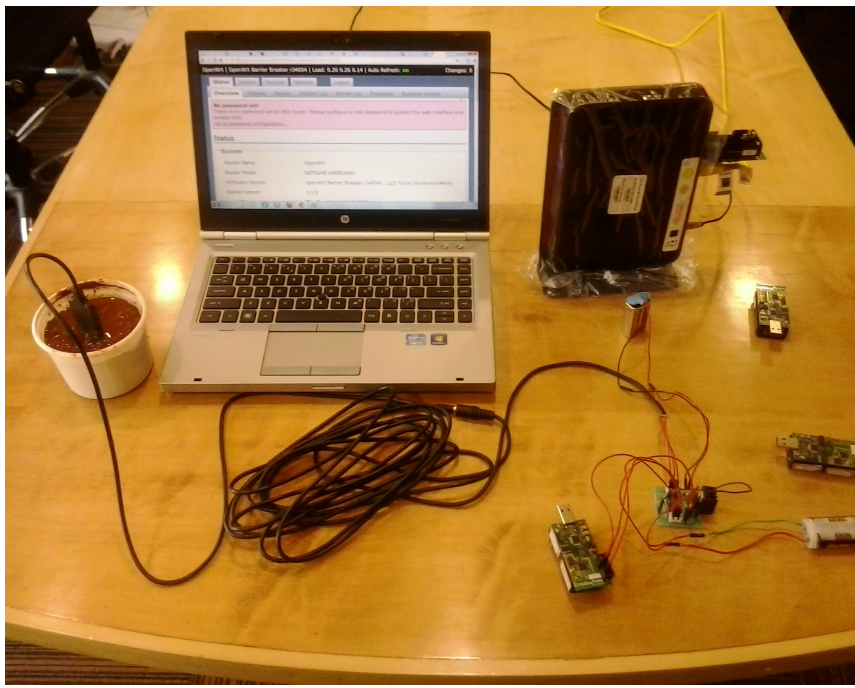


Agriculture Application Requirements

- ERNET India collaborates with ICAR institutions in project development:
  - Indian Institutes of Horticulture Research (IIHR)
  - Krishi Vigyan Kendras
  - Tamilnadu agriculture university
- Useful agriculture parameters suggested by ICAR scientists:
  1. Soil properties - electrical conductivity, temperature, moisture
  2. Soil nutrients - Nitrogen (N), Phosphorous (P), Potassium (K)
  3. Spectral reflectance for plant nutrients
- Support for remote field deployments & monitoring

Agriculture Sensor Network - Development setup

- **Hardware:**
  - Heterogeneous development platforms - TelosB, IRIS, AVR Raven. (Our CoAP based agriculture usecase is based on TelosB)
  - Soil Sensor: Decagon 5TE Soil Sensor
  - Netgear WNDR 3800 running OpenWRT configured as 6LoWPAN Edge Router
- **Software:**
  1. Operating System: Contiki 2.6
  2. 6LoWPAN stack - Contiki μIPv6
  3. CoAP Stack - Contiki Erbium CoAP



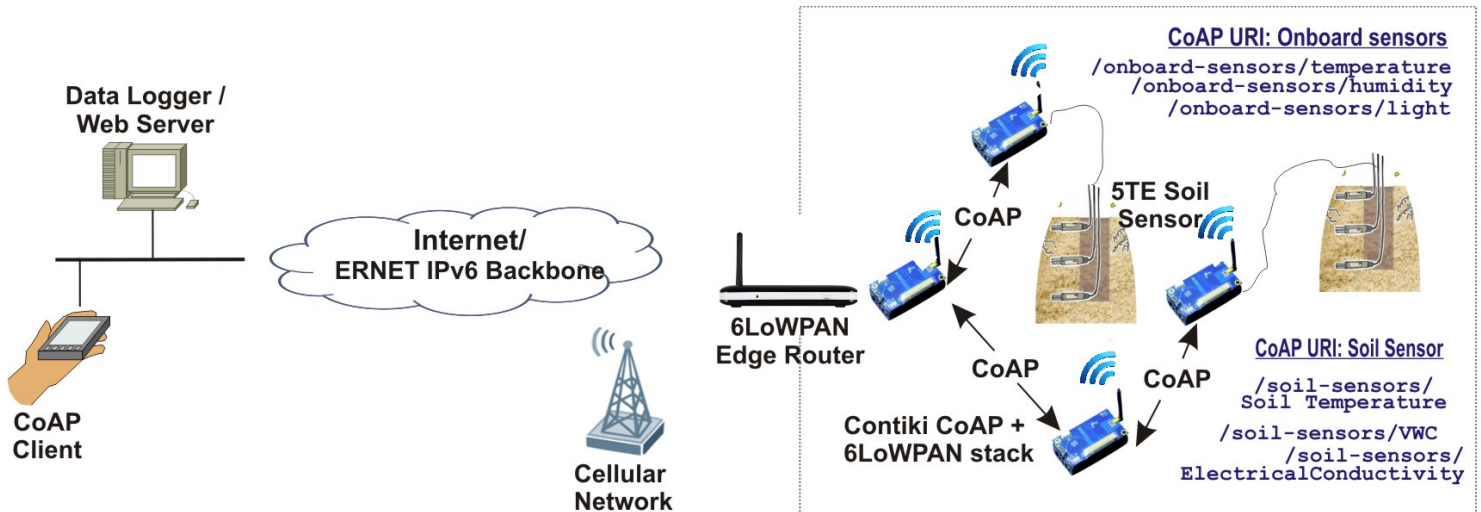
Modeling Soil Sensor Properties as CoAP Resource

- CoAP resource parameters - resource name, methods supported, URI Path string, resource type.
- Each resource has to implement an associated handler function
- CoAP response can be plain text, xml, JSON based on client requested format
- Example:

1. `RESOURCE(temperature, METHOD_GET, "onboard-sensors/temperature", "title="Sensirion Temperature Sensor (supports JSON)";rt="TemperatureSensor"");`
2. `RESOURCE(vwc, METHOD_GET, "soil-sensors/VWC", "title="5TE Soil Sensor (supports JSON)";rt="SoilSensor"");`

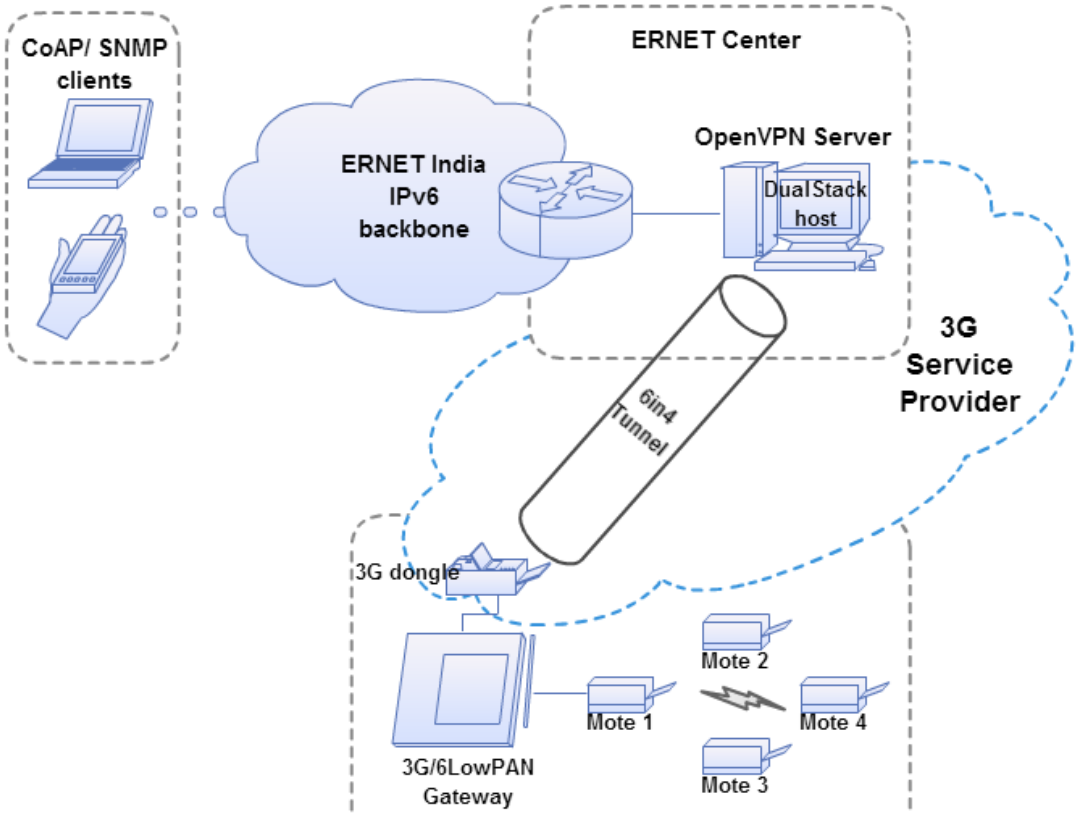
Agriculture Sensor Deployment Architecture & Plans

- **WSN:** – Wireless Sensor Network comprises of motes running a WSN application and a light-weight CoAP server
- **6LoWPAN border router (6LBR)** – The 6LBR acts as a gateway between the 6LoWPAN field network and the IPv6 backbone connecting through WiFi or 3G.
- **PAN Coordinator** – Central controller for the WSN.
- **CoAP client** – It is located remotely over the IPv6 network and enquire the WSN by invoking commands like CoAP GET /CoAP PUT.
- **Database/Web Server** – Used for logging sensor data for offline access (by the farmers or scientists).



ERNET connectivity using 6LoWPAN Gateway

- **OpenVPN Server** – 6in4 tunnel establishment from Pandaboard to ERNET center for end-to-end IPv6 using OpenVPN
- **Pandaboard** – 3G/6LoWPAN Gateway, OpenVPN client

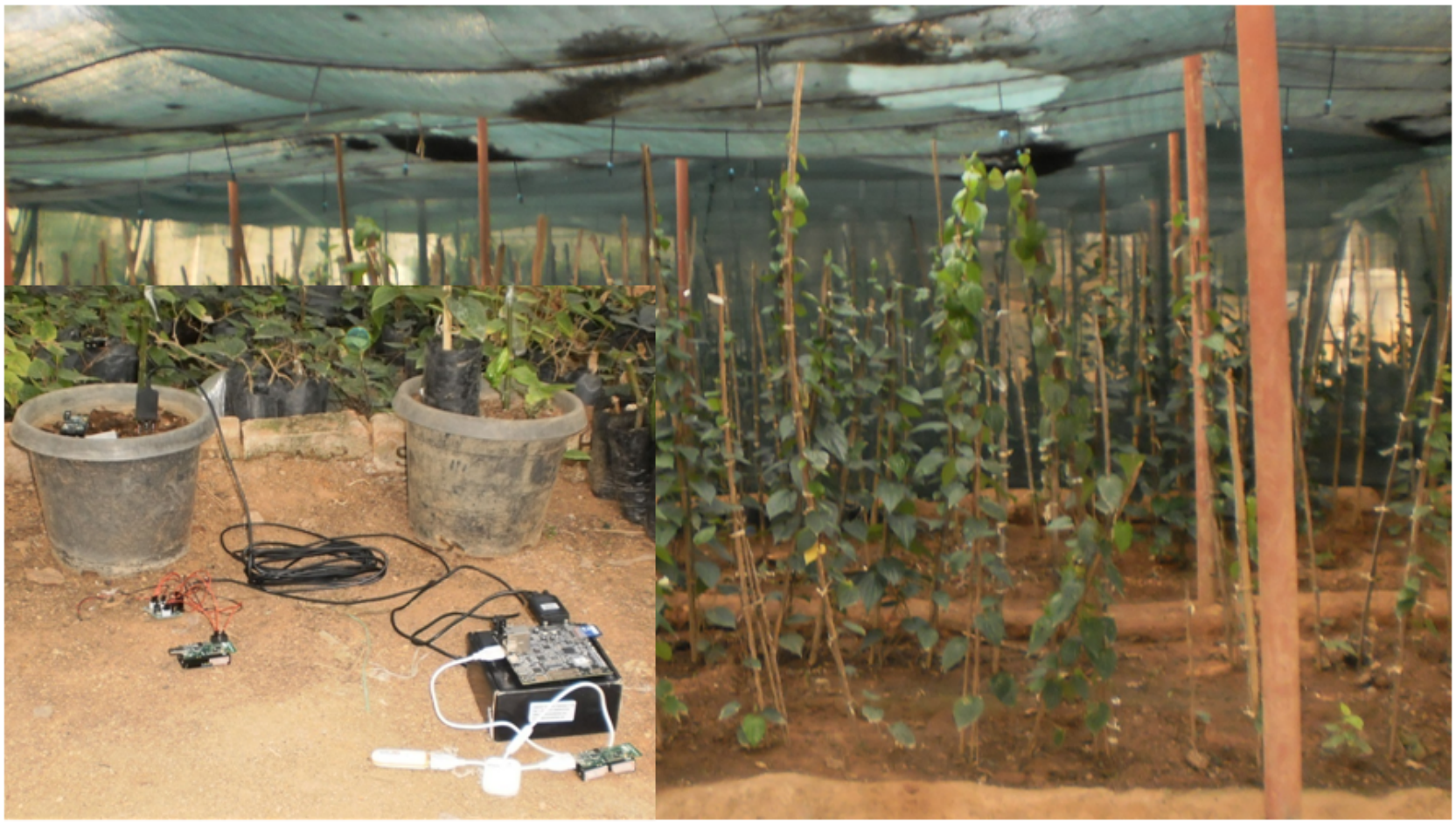


Implementation

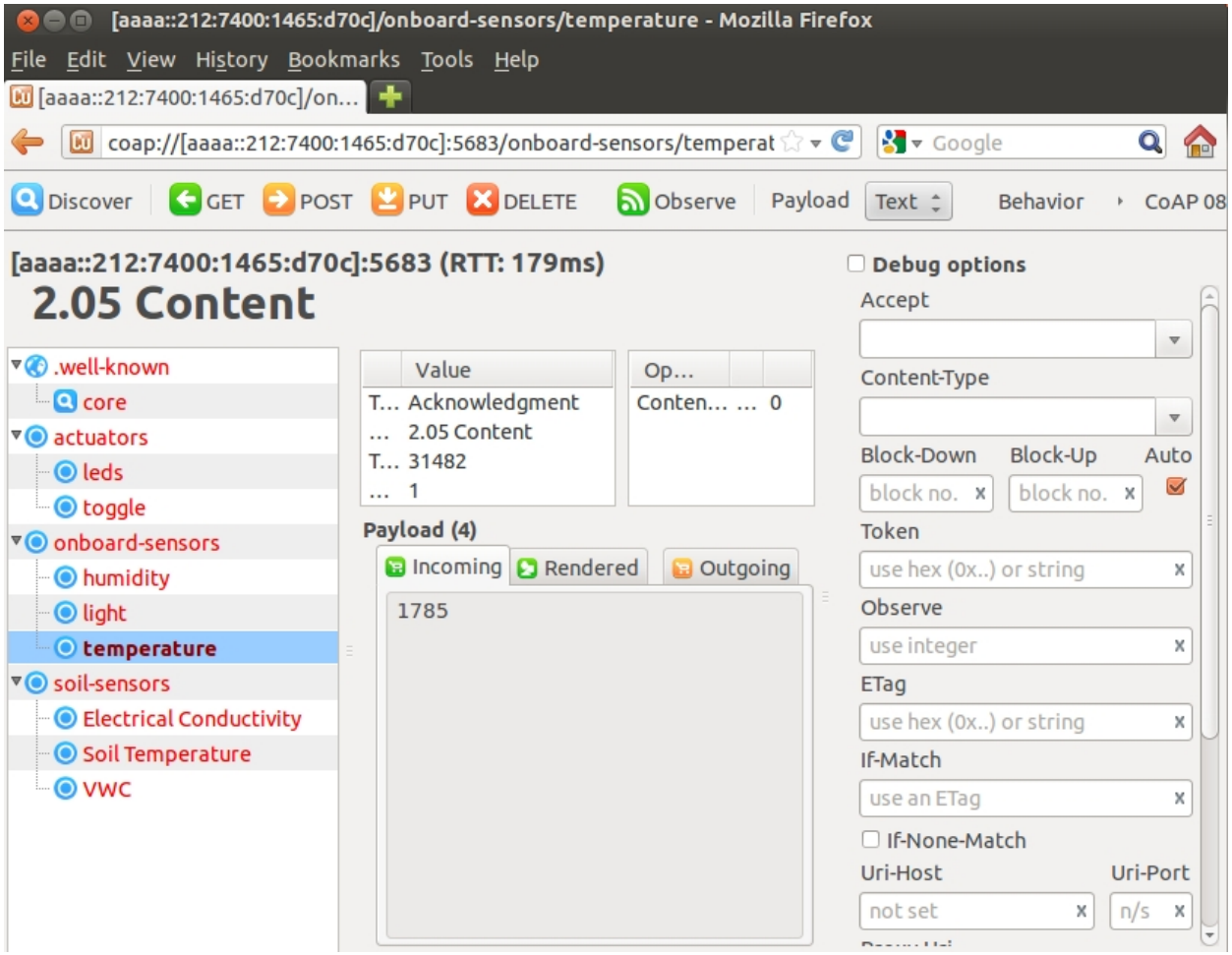
- **Hardware:**
  - **TelosB** – IEEE 802.15.4 compliant, MCU TI MSP430, Chipcon CC2420.
  - **Soil Sensor** – 5TE from Decagon supporting Soil temp., moisture and electrical conductivity.
  - **WiFi/6LoWPAN Gateway** – Netgear WNDR 3800
  - **3G/6LoWPAN Gateway** – Pandaboard ES that uses TI OMAP4460 SoC.
- **Software:**
  - **Contiki** – Open source OS for Internet of Things.
  - **OpenWRT** – Linux based firmware for embedded devices.
  - **Fedora18-panda-armhfp** – Fedora linux for Pandaboard.




Agriculture field – KVK Hirehalli



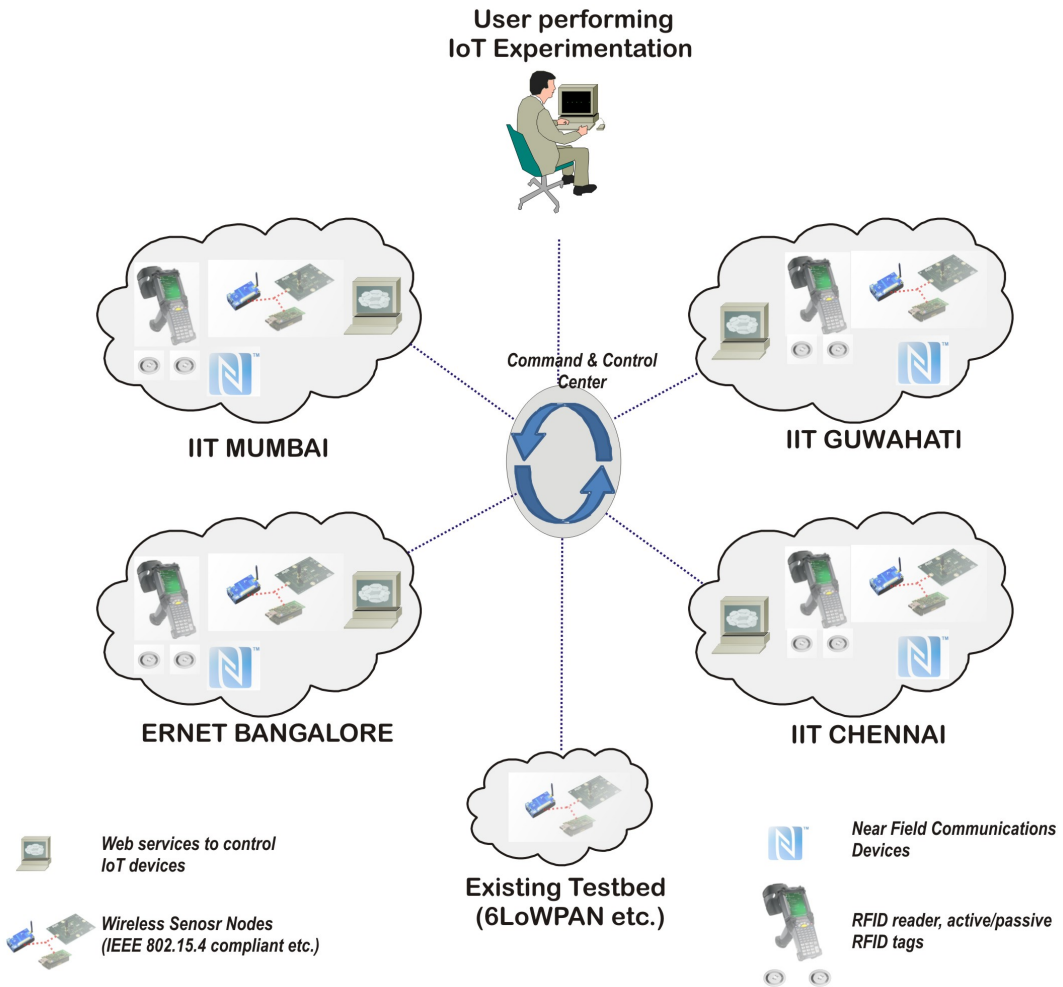
Web based monitoring



IoT Testbed plans

- Implementing IoT testbed comprising heterogeneous legacy and possible new types of devices
- Support IoT experiments to benefit academic and research community in improving the knowledge of IoT hardware and software infrastructure
- Semantic technologies and ontology development to the benefit IoT community
- Help scientific community in enhancing their knowledge about IoT and its relevance to their application domain (smart agriculture, smart health, smart grid)
- Facilitate IoT innovation enhancing its impacts and define necessary standards for IoT
- Use IoT to the benefit of the society

Distributed IoT Testbed



Thank you!, any questions?

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