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Broadcast Communication in IoT Network using Contiki-Cooja Simulator

Shrey Gupta[1], Inderjeet Rajput[2]

[1,2]Student of B.Tech in Electronics and Communications Engineering, University School of Information Communication and Technology (USICT), Guru Gobind Singh Indraprastha University (GGSIPU), Sector-16C, Dwarka, Delhi, India

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Abstract - *Internet of Things (IoT) is being used extensively in today's world as it revolves around connecting several physical devices with the help of things like sensors. Various types of communications like human to machine and vice versa are done in a complex wireless sensor network (WSN) to deliver information. In several cases, a device is required to send the same type of data to contrasting receivers simultaneously that is known as broadcast communication. The main focus of the proposed work is to implement and analyze broadcast communication between sensor nodes with the help of the Cooja network simulator in the Contiki operating system.*

Key Words: **Internet of Things (IoT), Communications, Wireless Sensor Network (WSN), Broadcast, Contiki-Cooja Simulator**

1. INTRODUCTION

Today, intelligent technologies like smart homes, smart water networks are foundation frameworks that associate our reality more than we at any point thought conceivable. The normal vision of such frameworks is generally connected with one single idea, the internet of things (IoT), where through the utilization of sensors intelligent monitoring and management can be achieved. In a particularly refined unique framework, gadgets are interconnected to communicate valuable estimation data and control guidelines through disseminated sensor networks. A wireless sensor network (WSN) consists copious amount of sensor nodes that detect different types of physical phenomena. WSN is considered a vital technology to be used in IoT instead of wired solutions.

1.1 Types of Communications in IoT

In a vast IoT network, various smart devices communicate with each other to trade data for the smooth functioning of the system. The devices are implanted with kinds of sensors that enable communication between them. Some types of communication in IoT are described below.

- **Human to Machine (H2M):** Type of communication where human gives input to an IoT device in the form of text, speech, and image is known as H2M communication. For performing an activity on a device that requires voice recognition, speech input is needed which is then analyzed by sensors and actuators to produce the desired result. The H2M is user-friendly and easy to access by adhering to the instructions. Some examples of H2M are facial recognition, bio-metric system, and voice recognition that can be seen in Figure 1.

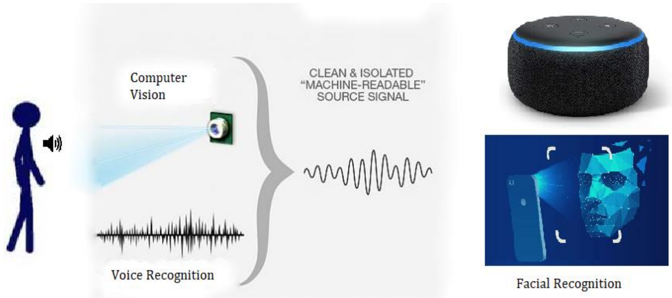


Figure 1: Human to Machine (H2M)

- **Machine to Machine (M2M):** This is a form of communication where two devices on a network exchange data autonomously by tapping into the sensor data and conveying it over the network. The choices are made by machines themselves through Artificial Intelligence and Machine Learning without manual assistance by humans. M2M provides proactive monitoring and some of its main applications include asset tracking and monitoring in warehouse (Figure 2), smart meters for tracking and billing, smart home devices that control HVAC systems.

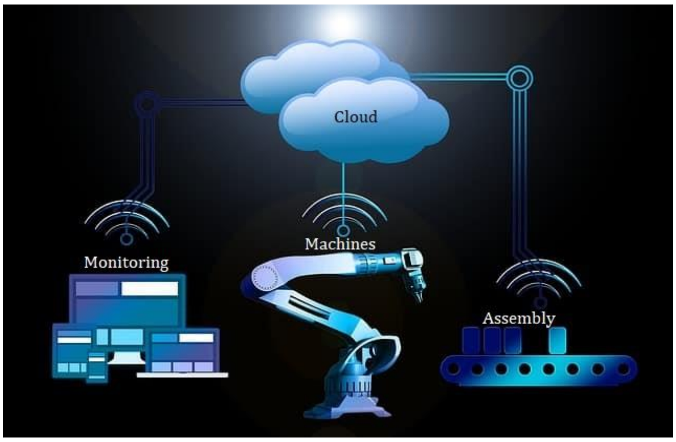


Figure 2: Machine to Machine (M2M)

- **Machine to Human (M2H):** It is a category of communication where machines get input through sensors and processes it using provided algorithms, thereby producing instructions in form of audio or visual signals which can conveniently be interpreted by humans. The most common examples are Smoke detectors which ring so that humans can hear and evacuate, Traffic signals which tell humans to stop or go, Blood Sugar monitors that advises when to use insulin as shown in Figure 3.

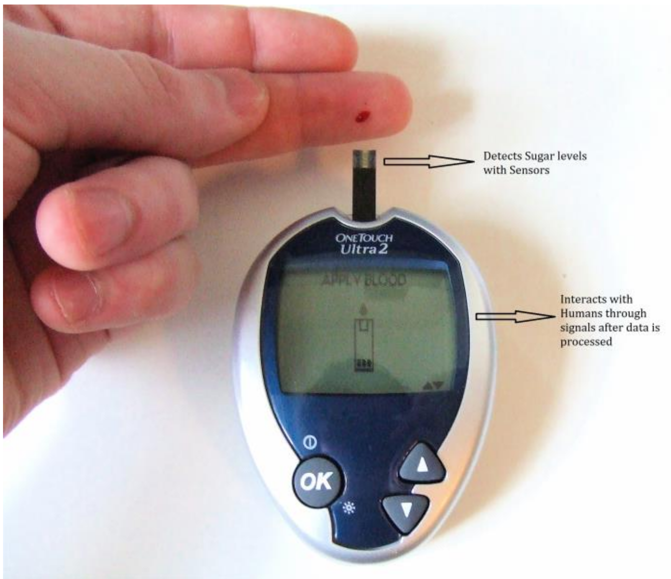


Figure 3: Machine to Human (M2H)

1.2 Broadcast Communication

Broadcast communication can be characterized as the systematic circulation of any information or data intended for concurrent reception by the dispersed audience with appropriate receiving equipment. Broadcast is meant for general public reception as opposed to private signals that are bound for particular receivers.

Consequently, a broadcast communication network can be described as a network that uses broadcasting for communication that means they take messages from one sender and distribute it across all nodes in the network. Broadcast communication is a type of machine to machine M2M) communication in the IoT network.

1.2.1 Pros and Cons of Broadcast Communication

Some advantages of broadcast communication are given below.

- Broadcast communication provides better utilization of all the available resources.
- This also has no limit, meaning that events can be broadcasted as long as required.
- Broadcast networks also allow the option of multicasting in the network.

Disadvantages associated with broadcast communication are mentioned below.

- Not all the networks available support broadcasting, like frame relay, X.25 don't have broadcast capabilities.
- Broadcasting can be susceptible to Smurf attack that is a type of Denial of Service attack.

1.2.2 Applications of Broadcast Communication

Some of the major applications of broadcast communication in IoT are listed below.

- **Home Automation-** A wide array of IoT devices are employed in home automation and broadcast communication will play a crucial role in teaming up such devices. The data is collected by sensors which is then processed and broadcasted at each endpoint so that the devices can automatically perform tasks while the user is pre-occupied like turn off appliances when the user leaves the house, regulate temperature.

- **Entertainment Industry-** A broadcast network in theatres can alter the ambiance of the room with the aid of sensors in accordance with the content being consumed to provide a multi-sensory experience. This could be a light and sound adjustment, or a vibrating chair.

- **Sports-** IoT devices deployed at sports venues can be set up in a broadcast network so that the data collected through sensors can broadcast to every node which can assist in making decisions and providing stats directly to fans.

- **Healthcare-** The monitoring devices can be set up on a broadcasting network so whenever the sensors detect any anomaly it can readily be broadcasted to each node and emergency assistance and/or medicines can be provided.

2. THE PROPOSED METHODOLOGY

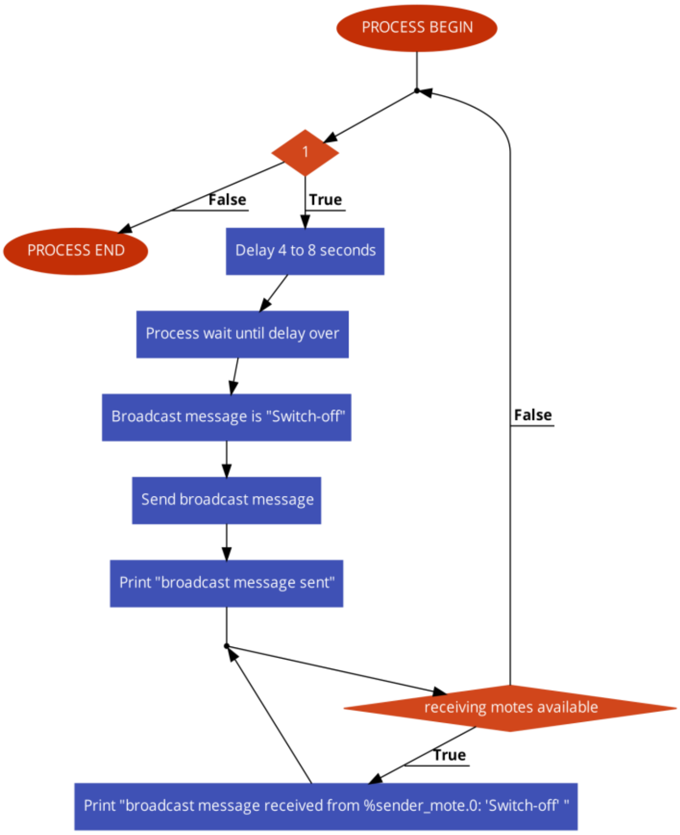
Due to the increasing demand for Internet of Things devices, it has become a necessity to connect all similar devices to a solitary control such as a mobile phone to increase efficiency. Users ought to have a choice that would permit them to operate similar IoT devices with one command rather than giving a command for every device separately. Broadcast communication gives users an option to send a single command to all of the similar IoT devices such as lights.

2.1 Rime Network Stack

Rime is a lightweight layered correspondence stack for sensor networks that gives a bunch of correspondence natives going from best-exertion unknown local to solid network flooding. The motivation behind Rime is to work on the execution of sensor network protocols and work with code reuse. Contiki incorporates the Rime stack as an option for a low-power wireless network, which doesn't need all the intricacy of the conventional stacks.

2.2 Code Flowchart

This sub-section has a flowchart made with commands given to the motes by the c-language file that contains the code for broadcast communication.



Flowchart 1: Broadcast Communication

After starting the simulation (1) there is a delay introduced of about four to eight seconds. After the delay the broadcast message is set to "Switch-off", then the sender mote sends the message to the receiver motes. A statement will be printed that depicts the end of sending the broadcast. A statement is then printed for all the receiving motes, that contains the information of the message received and the sender mote.

2.3 Simulation Experiment

This sub-section contains the simulation of broadcast communication in a wireless sensor network that also makes up the IoT network. The simulation is done in Contiki-Cooja Simulator with the use of sky mote. We use Rime Network Stack in the Contiki-Cooja simulator for the simulation of Broadcast communication.

We use six sky motes and compile a c-language file that contains the code for broadcast communication in every mote. The transfer of packets from one mote to another is done as per the commands written in the code. The motes are positioned such that all of them are in the transmission range of each other as shown in the Simulation Network in Figure 4. The "Start" button on the Simulation Control panel (Figure 5) has the role of starting the simulation. After the start of the simulation, a mote is selected that will send a broadcast message to the other five motes. The same process is continued for every mote until the simulation is stopped by the "Pause" button on the Simulation Control panel.

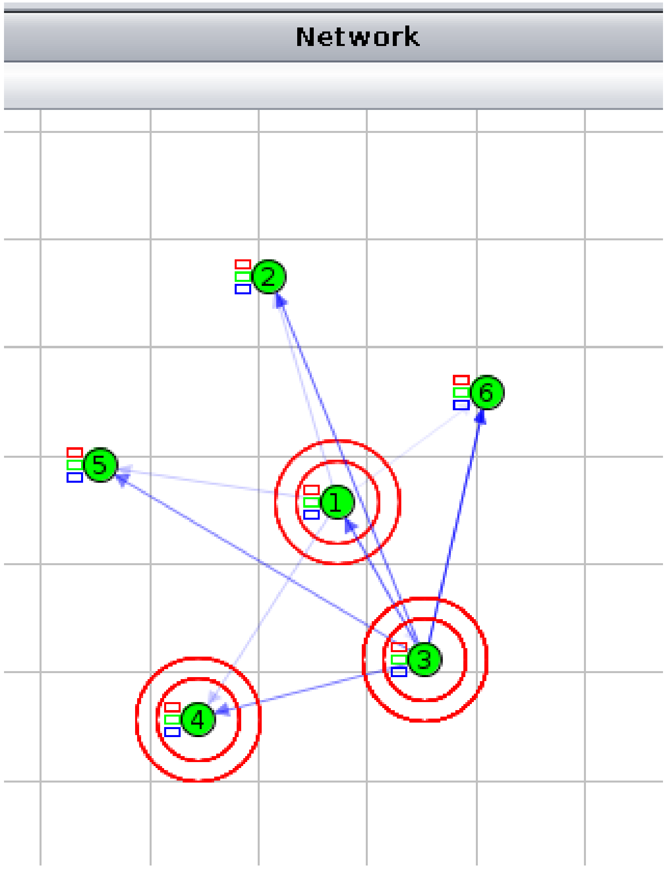


Figure 4: Simulation Network

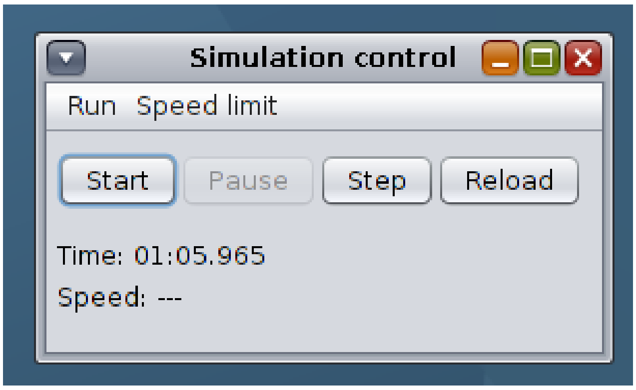
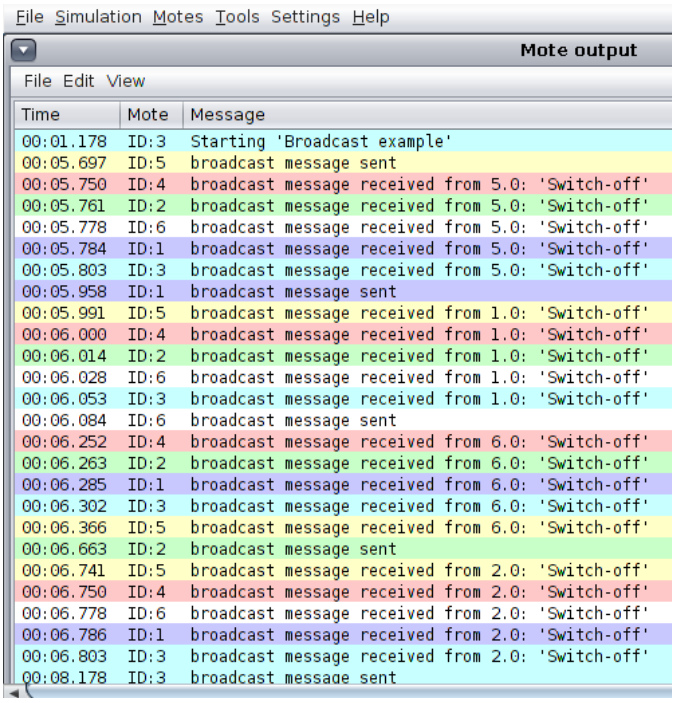


Figure 5: Simulation Control Panel

2.4 Simulation Result

When the simulation is started, mote 5 is chosen as the sender that broadcasts the message "Switch-off" as shown in the Mote Output in Figure 6. All the other motes (mote 1, 2, 3, 4, and 6) are the receivers of the broadcast message. It can be seen in the mote output that all the other motes receive the message "Switch-off" from the mote 5. After the broadcast by mote 5 is complete, mote 1 is selected to be the sender of the same message whereas the rest of the motes behave as receivers. The process of broadcasting by selecting a mote to be the sender continues until the simulation is stopped.

It can also be inferred from the mote output that the time taken by mote 5 to send the broadcast message to all the other motes is 106 ms (milliseconds). So rather than sending the same message to each mote individually, it is more convenient to broadcast the message to other motes at the same time as it decreases the required efforts by the user.


File Simulation Motes Tools Settings Help
Mote output
File Edit View

Time	Mote	Message
00:01.178	ID:3	Starting 'Broadcast example'
00:05.697	ID:5	broadcast message sent
00:05.750	ID:4	broadcast message received from 5.0: 'Switch-off'
00:05.761	ID:2	broadcast message received from 5.0: 'Switch-off'
00:05.778	ID:6	broadcast message received from 5.0: 'Switch-off'
00:05.784	ID:1	broadcast message received from 5.0: 'Switch-off'
00:05.803	ID:3	broadcast message received from 5.0: 'Switch-off'
00:05.958	ID:1	broadcast message sent
00:05.991	ID:5	broadcast message received from 1.0: 'Switch-off'
00:06.000	ID:4	broadcast message received from 1.0: 'Switch-off'
00:06.014	ID:2	broadcast message received from 1.0: 'Switch-off'
00:06.028	ID:6	broadcast message received from 1.0: 'Switch-off'
00:06.053	ID:3	broadcast message received from 1.0: 'Switch-off'
00:06.084	ID:6	broadcast message sent
00:06.252	ID:4	broadcast message received from 6.0: 'Switch-off'
00:06.263	ID:2	broadcast message received from 6.0: 'Switch-off'
00:06.285	ID:1	broadcast message received from 6.0: 'Switch-off'
00:06.302	ID:3	broadcast message received from 6.0: 'Switch-off'
00:06.366	ID:5	broadcast message received from 6.0: 'Switch-off'
00:06.663	ID:2	broadcast message sent
00:06.741	ID:5	broadcast message received from 2.0: 'Switch-off'
00:06.750	ID:4	broadcast message received from 2.0: 'Switch-off'
00:06.778	ID:6	broadcast message received from 2.0: 'Switch-off'
00:06.786	ID:1	broadcast message received from 2.0: 'Switch-off'
00:06.803	ID:3	broadcast message received from 2.0: 'Switch-off'
00:08.178	ID:3	broadcast message sent

Figure 6: Mote Output

3. CONCLUSION

Internet of Things is considered the future of all devices as it makes most of the work easier by decreasing human intervention to the lowest degree. Most of the homes are now equipped with smart lights that are controlled using an application on the user's mobile phone, rather than switching off every light individually it is way more efficient to broadcast a switch-off command to every light with a single click. The research work focuses on broadcast communication between sensors. A simulation on the Contiki-Cooja simulator is done where a sensor broadcasts a message "Switch-off" to the other five sensors simultaneously. It was seen that the time taken to send the message to all the sensors is just 106 ms (milliseconds), moreover the user has an option to do a job that would take five clicks in just one click by broadcasting the command.

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