WInternet and Its Applications for Transportation Systems

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1. Introduction

Internet of Things (IoT) is becoming popular in recent years and has attracted great attentions from both academics and industry. IoT is considered to be a cyber-physical network system that can connect physical objects together for monitoring and controlling purposes through cyber technologies. As such, IoT would be able to greatly extend human being's capability to interact with physical world. Though IoT has great potentials and many practical IoT systems have been built, there are some fundamental issues need to be addressed.

Most of the current IoTs are small-scale specialized networks. Though these networks have been able to connect physical objects together in local regions, and allow controlling physical objects through cyber technologies, the resources among these small networks are seldom shared. Furthermore, since most of these networks are designed for special purposes with dedicated protocols, they usually are not inter-connected. In this paper, we introduce WInternet, an IoT prototype designed by our team intending to address these issues by using generalized protocols to interconnect small specialized IoTs. If selected, in the workshop, we will demonstrate how WInternet interconnects several video surveillance systems and hence provides tracking services to transportation systems, e.g., armored cash carrier vehicles.

2. Architecture

WInternet is designed with horizontal inter-connection as a basic principal. WInternet adopts a dual-layer architecture, as shown in Figure 1. At the lower layer, WInternet uses Internet as communication media. At the upper layer, WInternet provides services that usually are common in IoTs. These services include communication, computing, and security services.
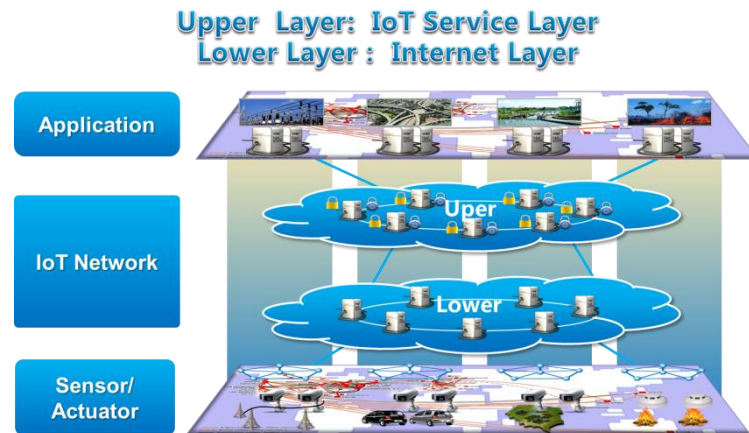
Figure 1.   Dual-Layer WInternet Architecture

WInternet consists of three types of sub-networks, i.e., Edge Network, Backbone Network, and Access Network. The Edge Network is the sub-network that connects physical objects into the WInternet. The Backbone Network is the core network that is mainly responsible for data computing and routing. The Access Network is the part of WInternet for information delivery (to applications at high layers) by using existing standard technologies, e.g. HTTP. The overall topology of WInternet is shown in Figure 2.
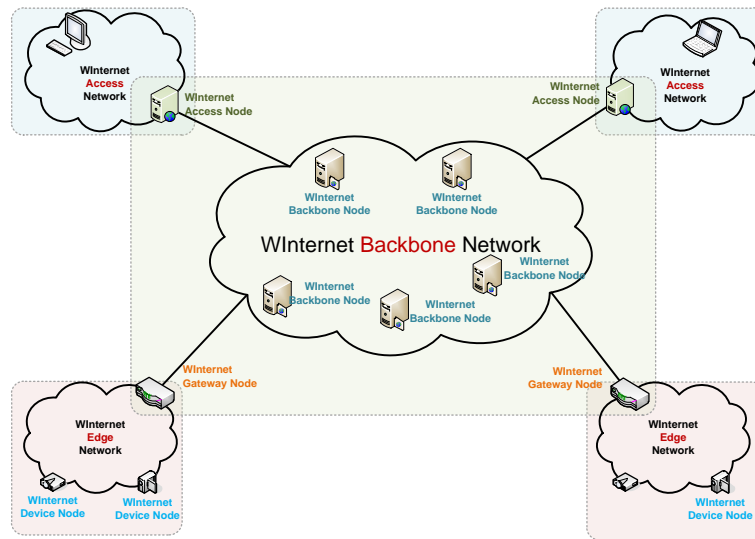
Figure 2. Network Topology of WInternet

The Edge Network includes two types of nodes, that is, WInternet device node and WInternet gateway node. WInternet device node is the one that directly senses or controls physical objects, e.g. a temperature sensor, or a power switch. WInternet gateway node is a component that can accept data from device node and deliver to the backbone nodes. WInternet gateway node is also responsible for accepting commands from the backbone network and forwarding them to the device nodes. WInternet Gateway node is accessible by the backbone nodes publically, while the WInternet Device node could only be accessed through the Gateway nodes.

The WInternet Backbone Network consists of a group of Netlet nodes. The main function of a Netlet Node is to execute "Netlets". A Netlet is a special program executed on the node for processing data. Netlet could be dynamically installed to netlet nodes when needed, and could be removed when the processing is done. The input data of a Netlet come either from other Netlet nodes, or directly from Gateway nodes. The output data of a Netlet can then be subscribed by other Netlet nodes for further processing.

WInternet Access Network consists of a number of WInternet access nodes. A WInternet access node is a node connecting to one or more Netlet nodes on one side, and to end-user computers on the other end. The main role of the access node is to transform the Netlet output into other standard format for viewing by human being or applications. A typical example is a node that converts the output of a Netlet into a standard HTML web page for human being viewing.

3. Protocols

WInternt Protocol stack includes three major components, i.e., pipe communication protocols, Netlet computing protocol, naming and searching protocols. Pipe protocol runs on top of TCP/IP protocol stack, and provides common communication services. Netlet computing protocol defines the common design requirements and interface specification, as well as run-time management protocols for netlets. The overall relationship of the protocols is show in the figure below.
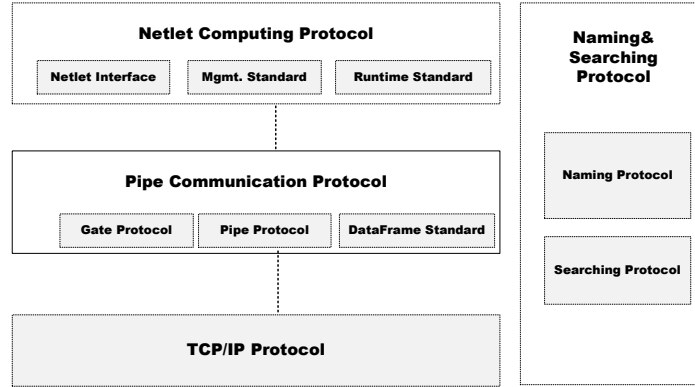
Figure 3. Protocol Stack of WInternet

The Pipe Communication Protocol includes three sub-components, e.g., Gate Protocol, the Pipe Protocol, and the DataFrame Standard. Gate Protocol is used for the communication between device node and gateway node. The pipe protocol is mainly used between gateway node and backbone node, or among backbone nodes. The dataframe protocol defines the common data structure of the data sent among nodes. The naming and searching protocol suit consists of a naming protocol and a searching protocol. They define the standard for naming the objects and services in WInternet, and the standard for performing searching in the network, respectively.

4. Implementation and Demonstration

WInternet V1.0 has been implemented. Currently the network connects devices at several Chinese Institutions, including Tsinghua University, Tongji University, the University of Macau, and the Chinese Academy of Sciences. Based on WInternet V1.0, we have built a vehicle tracking system that uses WInternet to interconnect several video surveillance networks which have already been installed in a city. The system can track a designated vehicle by the following functions:

1. To recognize the license id at each device node that connects to a camera; and
2. To upload only those video images that contain the designated vehicle (with a given license id) to access node (via gateway nodes).

Please note both of these functions are performed by executing specially developed netlets. Pipe connections are created among relevant nodes in order to deliver required video images to applications. In our demonstration system, video images are delivered to a command center where a human operator will monitor the tracked vehicle. Figure 4 shows run-time displays at the command center.

Figure 4. Run-Time Displays of WInternet based Vehicle Tracking System

5. Conclusion and Future Work

We have discussed WInternet which has a unique architecture that can meet the requirements of IoT related applications. Based on WInternet V1.0, we also developed a demonstration system that can effectively track designated vehicles through currently installed video camera systems. Our demonstration shows that WInternet can not only greatly satisfy the real-time, privacy, and scalability requirements, bus also significantly reduce the costs of developing cyber-physical systems. WInternet achieves this by inter-connecting small-scale special purpose networks. This is similar to the situation in early 1980's when TCP/IP was developed and was used to inter-connect many small local area networks.

Currently, we are considering new applications based on WInternet V1.0. The candidates include a dynamic monitor system for nuclear power disasters where it is necessary to interconnect several heterogeneous IoTs including smart grid, environmental monitoring system, weather monitoring system, etc. WInternet V2.0 is also being planned which will have much strong interconnecting capabilities.