Research on Self-adaptive Wireless Sensor Network Communication Architecture Based on Ptolemy II

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Abstract. For the existing heterogeneous wireless sensor network architectures, different data link layers lack a common structure. To solve the problem mentioned above, this paper has proposed the concept of attribute assembly layer, and based on the hierarchical heterogeneous modeling of Ptolemy II, an adaptive architecture for wireless sensor network has been put forward. Experimental results show that this architecture has a low memory occupation and time cost. It unifies the data link layers for heterogeneous networks, and it is well compatible with the existing platforms, communication protocols and network mechanisms. The proposed architecture has good adaptive capacity, and it can apply to potential communication protocols and mechanisms.

Keywords: WSN, Network Architecture, Ptolemy II, Self-adaptive, Attribute Assembly Layer.

1 Introduction

With the rapid development of wireless communication technology and wireless sensor networks, there emerge lots of typical wireless communication technologies, mainly including 3G [1] based wireless WAN, IEEE 802.16 [2] based wireless MAN, IEEE 802.11 [3] based wireless LAN, and wireless PAN based on IEEE 802.15[4]. For the diversity of existing wireless communication technology, applications and protocols of the wireless network would run over different link layers, and data transferring also can’t depend on the same link-layer mechanism. Therefore, we need to consider that, over the existing communication protocol architecture for wireless sensor network, if there is a mechanism independent of link layers to develop applications and protocols.

Communication protocol architecture with common operability has a good code reuse, and it can meet the needs of compatibility, interoperability and scalability for the link layer. Thus, such architecture has a great advantage in the development for wireless sensor network. Many organizations associated with sensor network have put forward various communication protocol architectures for heterogeneous networks. For instance, J. Sachs.A has proposed the concept of general link layer (GLL) [5].
IETF has designed the architecture of 6LowPAN [6], shown as Fig 1.1 (b). This architecture can be well extended on the application and protocol. However, it hasn’t fundamentally solved the problem of automatic matching for protocols, but just adds a 6LowPAN adaptation layer to perform the protocol format conversion from IPv6 to IEEE802.15.4.

In order to ensure the adaptive capacity of communication architectures, this paper has proposed an adaptive general structure for sensor networks, shown as Fig 1.1(c), which is based on traditional network architecture, shown as Fig 1.1(a), and inspired by 6LowPAN. The proposed architecture has reassembled the network structure and brought in attribute assembly layer. The attribute assembly layer consists of two parts, which are the attribute factory and the assembly factory. The proposed architecture has been designed to adapt to different types of potential communication protocols, and such ability is revealed by the compatibility with the existing different link layers. The simulation experiments show that the adaptive network architecture can be well mapped to traditional wireless sensor network protocols, including packet distribution, packet collection, mesh routing, etc.

2 Adaptive Communication Architecture

2.1 Attribute Factory

The protocol stack of attribute factory has defined a serial of communication prototypes. Applications and protocols above the attribute factory can call any one or more communication prototypes. The protocol stack has a hierarchical structure, and a complicated protocol is composed of relatively simple protocols. The hierarchical structure for the protocol stack of attribute factory is shown as Fig 1.3.

The attribute factory supports the transmission prototypes of single-hop and multi-hop. The multi-hop prototype doesn’t specify how the packets through the network perform routing, and the routing work is assumed by the communication protocol above. The communication protocol chooses an appropriate next-hop address according to the header field of a packet. The separation of multi-hop model from routing protocol contributes to implementing any one or more types of routing protocol. When multiple types of routing protocol are needed, we only need to add them, and the specific transmission of multi-hop is done by communication prototype. In a certain sense, the communication model has provided a high abstraction of data transmission, and it has separated the transmission model from the protocol logic.

The attribute factory substitutes the header of a packet with some packet attributes, which contain the same information required in communication as the traditional packet header. Therefore, packet attributes are abstract representation for the data of header field. The attribute factory has predefined some packet attributes, including id of a packet, type of a packet, addresses of the sender and receiver, hop count, lifetime, number of retransmission, reliability, link conditions, etc. The application and protocol can also define additional attributes.