4.1 Introduction

Wireless Embedded Internet systems are usually designed for a specific purpose, for example a facility management network or for a simple home automation system. These two examples happen to have widely different application protocol requirements. Currently, large building automation systems are pre-configured to function in that environment, require management with e.g. SNMP, and often make use of industry-specific protocols such as BACnet. A home automation system on the other hand requires service discovery protocols such as SLP, and may make use of web-service style or proprietary protocols for data and management. What makes 6LoWPAN very different from vertical communication solutions is that the same network can be used by a large variety of devices running different applications thanks to the Internet model. All the protocols mentioned above can be run over the same IP network infrastructure, simultaneously. IP uses what is often called a *horizontal* networking approach.

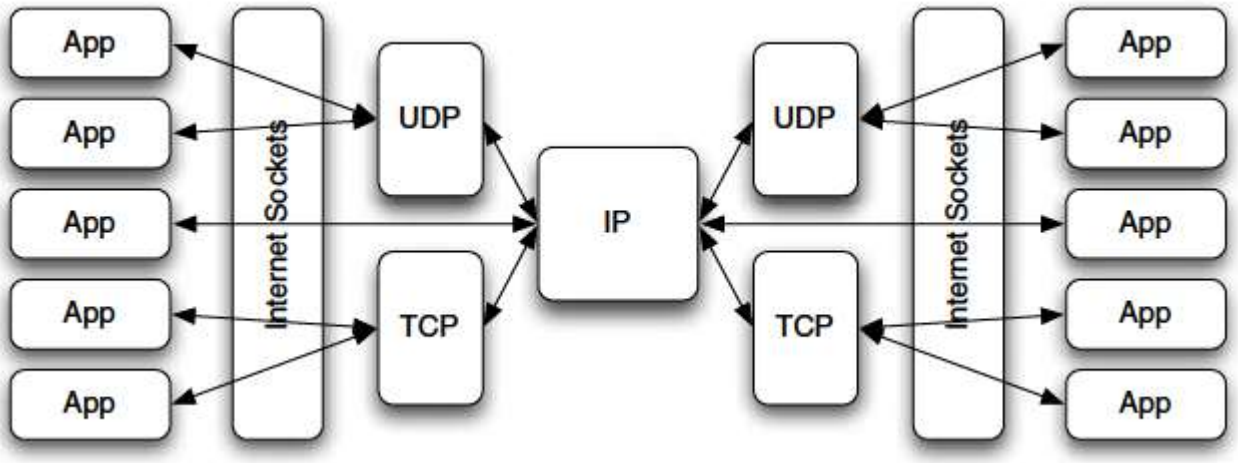

Figure 4.1.1 Applications process communication occurs through Internet sockets.

Although the Internet Protocol provides basic packet networking over heterogeneous links, it is UDP and TCP that allow for the large range of application protocols by providing *best-effort* (UDP) [RFC0768] and *reliable connection-oriented* (TCP) [RFC0793] multiplexed communications between application processes. IP protocols use a socket-based approach, where process *end-points* are identified by 16-bit source and destination port identifiers [RFC1122]. These are commonly called Internet sockets or network sockets.

The concept is illustrated in Figure 4.1.1 The communication between any two end-points is uniquely identified for each transport by a four-tuple consisting of the local and remote socket addresses:

{src IP address, src port, dst IP address, dst port}

Application protocols use a socket API to access *datagram socket* (UDP) and *stream socket* (TCP) transport services along with *raw socket* (IP) services within a protocol stack. The different types of sockets are completely independent of each other (e.g. UDP port 80 and TCP port 80 can be used simultaneously). 6LoWPAN supports the compression of UDP ports down to a range of 16 [RFC4944], which is useful because a LoWPAN usually has a limited number of applications.

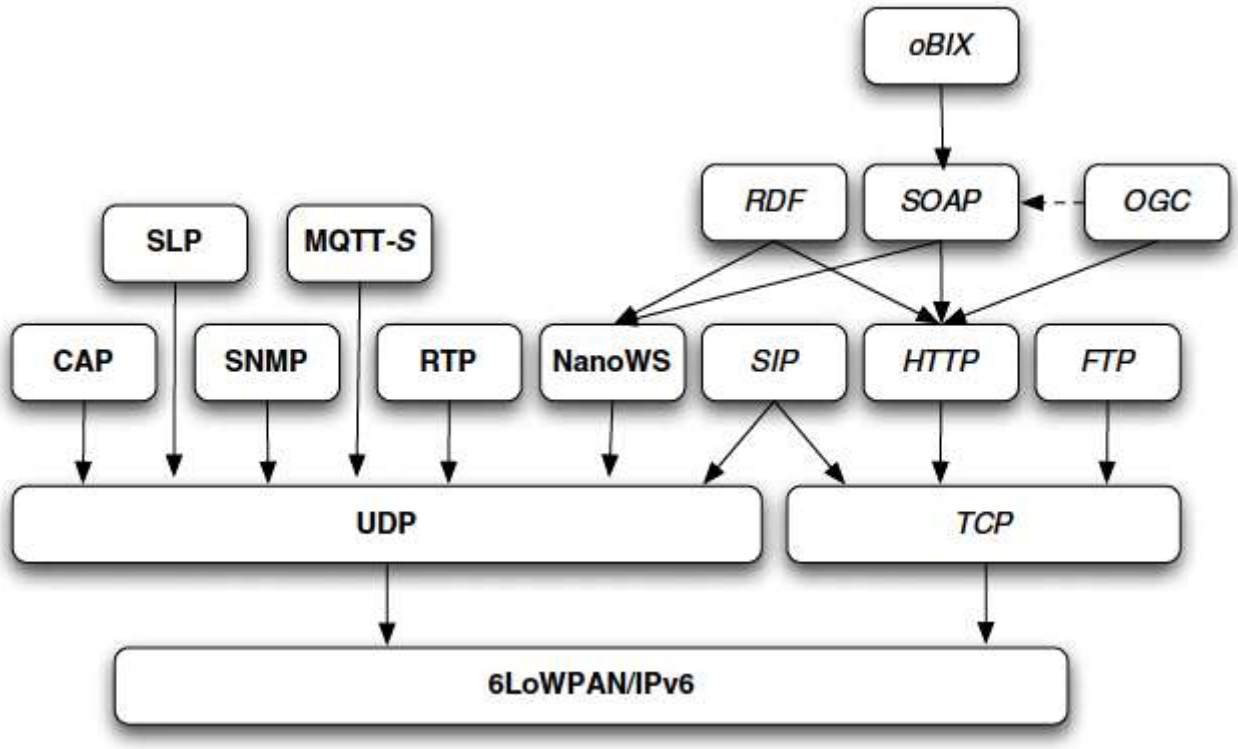

Figure 4.1.2 The relationship of common IP protocols.

Design Issues

Application protocols used over 6LoWPAN need to take a number of requirements into account which are typically not an issue over general IP networks. These issues include:

- Link layer: Link-layer issues include lossy asymmetrical links, typical payload sizes of 70–100 bytes, limited bandwidth, and no native multicast support.
- Networking: Networking related issues include the use of UDP, limited compressed UDP port space and performance issues regarding the use of fragmentation.
- Host issues: Unlike typical Internet hosts, 6LoWPAN hosts and networks are often mobile in nature during operation. Furthermore, battery-powered nodes use sleep periods with duty cycles often between 1–5 percent. A node may be identified in many ways, e.g. using its EUI-64, its IPv6 address or by a domain name, which should be taken into account.
- Compression: The small payload sizes available often require compression to be used on existing protocols. Issues to consider include header and payload compression, and whether it is performed end-to-end or by an intermediate proxy.
- Security: 6LoWPAN makes use of link-layer encryption which protects a single hop. Intermediate nodes are susceptible to attack, requiring sensitive application to employ end-to-end application-level security. Edge routers need to implement firewalls in order to control the flow of application protocols in and out of LoWPANs.

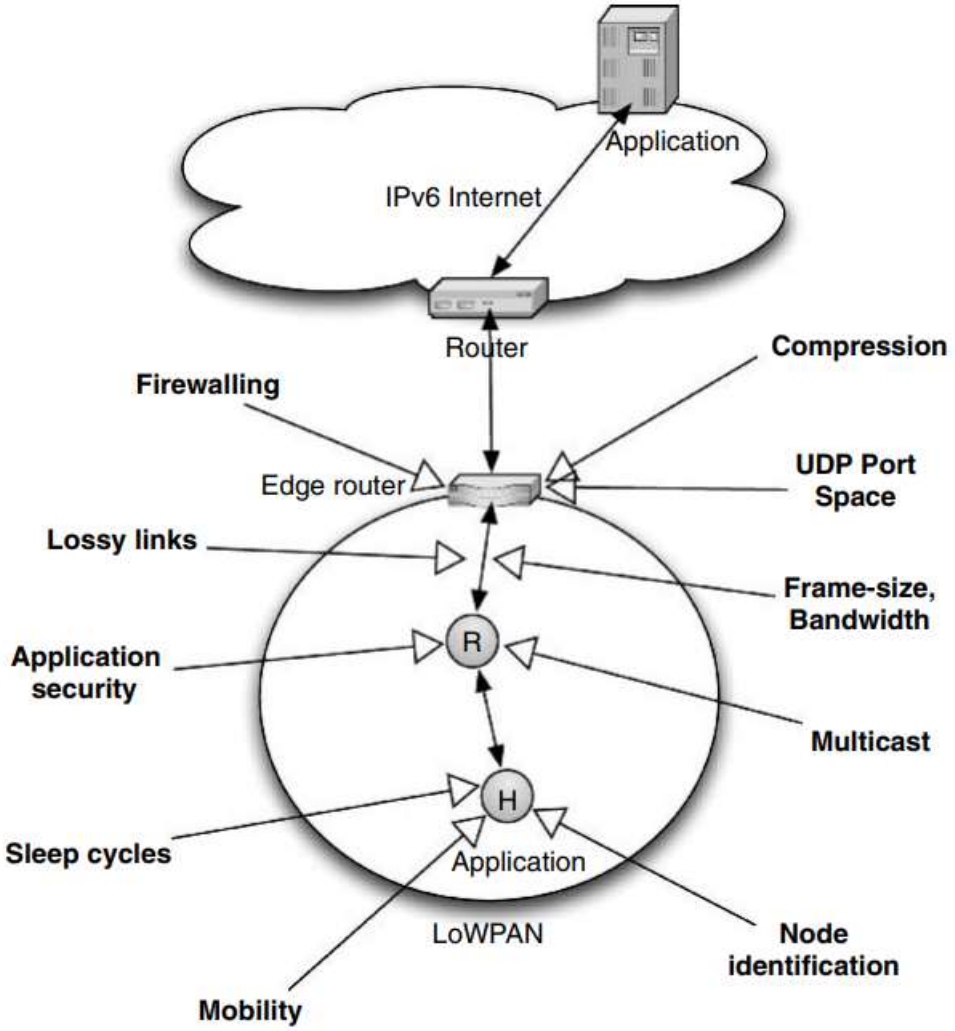

Fig 4.1.1 Application design issues to consider and where they occur in a LoWPAN.

Figure 4.1.1 illustrates where these issues typically occur in a LoWPAN. Mobility, node identification and sleep cycles are caused by node design and network properties. Intermediate 6LoWPAN Routers are a security risk, motivating end-to-end application security. The wireless link layer introduces bandwidth and frame size limitations. Finally, at the edge router we need to deal with compression, firewalls and UDP port space.