Advanced Nemo Mobile Sensor Web

As part of the GRC Sensor web task GRC was to work with Cisco to research and deploy advanced mobile networking technology applicable to mobile sensor platforms. As a result, GRC personnel developed a two-tier sensor web design. The first tier utilized mobile network technology to provide mobility [Figure 14]. The second tier, which sits above the 1st tier, utilizes 6lowpan (Internet Protocol version 6 Low Power Network) sensors. The entire network was IPv6 enabled.

The ArchRock IPv6 sensors (http://www.archrock.com/) were procured and integrated into the mobile ad hoc network. The output of some of these sensors is illustrated in figures 19 and 20.

GRC also purchase and IPv6 capable video sensor and has been able to establish connectivity with it via native v6.

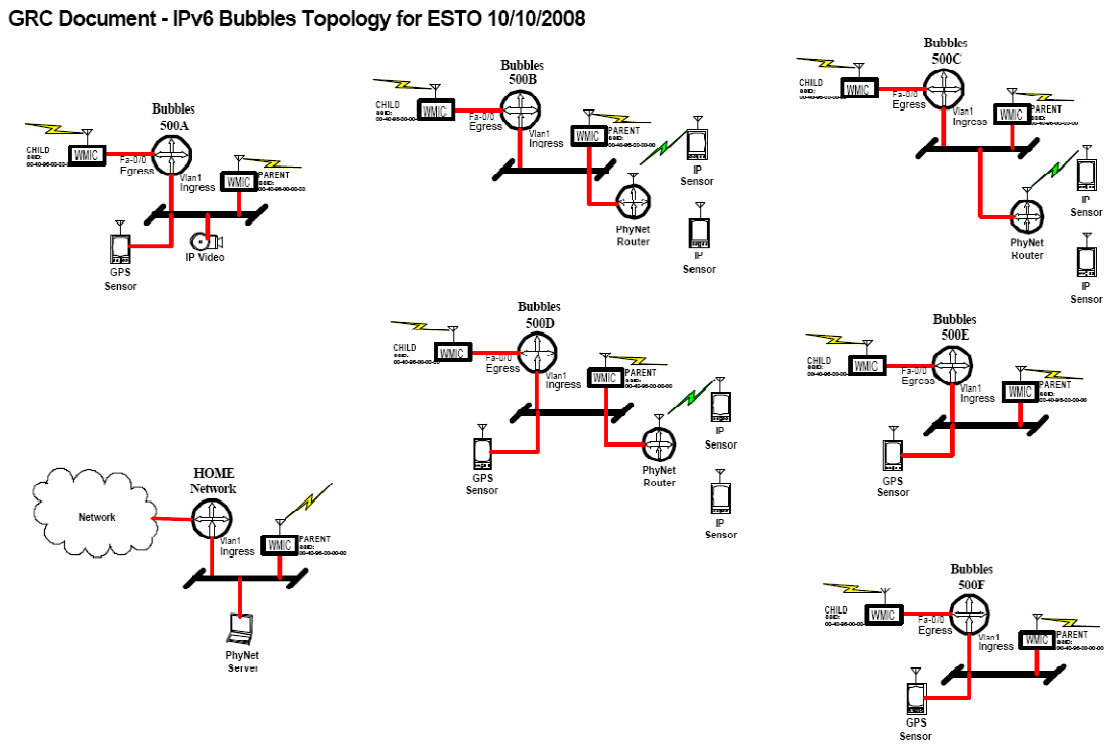

Figure 1: "Bubbles" IPv6 mobile ad hoc network

GRC utilized mobile ad hoc networking alpha software from Cisco System – France, known internally to Cisco as "Bubbles". Portions of the "Bubbles" specification has been taken up by the IETF Routing Over Low power and Lossy networks (roll) working group as a group of interrelated internet drafts [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**]. This protocol is directed toward low power sensor webs such as building and industrial controls and monitoring.

The manet software was originally debugged by Cisco in a wired network. GRC implemented a wireless network with radios on each interface. The initial result showed the route tables in the NEMO routers appearing to be accessible, but all not all nodes were truly accessible. GRC located and fixed the problems via network configuration and readdressing the network.

The mobile sensor web system field tests took place in late August and early September of 2009. Figure 15 shows a conceptual field deployment. Here, we only need to have 1 unit mobile to make the entire network have to adjust. Hence "network mobility" is exercised at each mobile router due to change in network topology. In order to remotely monitor each mobile node, we configured the network such that at certain points in the movement of Mobile node 1, every node is ever reachable. This is not necessary, but a matter of convenience for testing a debugging.

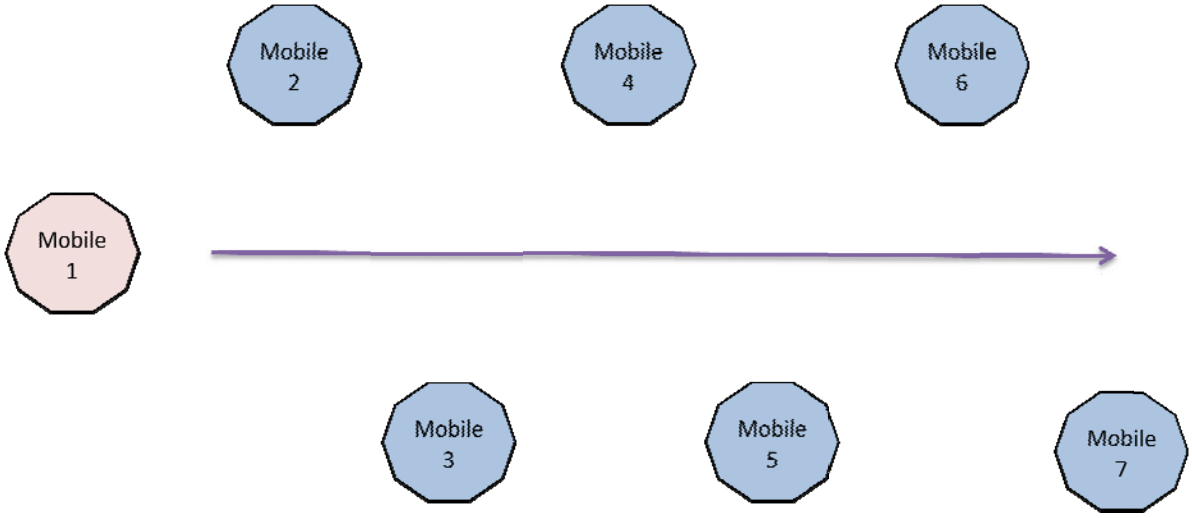

Figure 2: Mobile Network Notional Test Deployment

We did not implement any web services or sensor discovery. However, the entire system is reachable via the Web. Since our Home Router node is fixed we can easily register that address in the Internet Domain Name System (DNS). Thus, one should be able to enable access to mobile sensor web information using the Open *Geospatial* Consortium (OGC) specifications and standards.

Note, the remaining data presented on the mobile sensor web was obtained via a standard IPv6 enabled web browser.

In order to monitor the mobile nodes, GRC developed a simple network management system to show location of the nodes and simple status. Figures 16 and 17 show two configurations of the same set of seven mobile nodes along with the 6lowpan sensors. The 6lowpan routers are labeled “PhyNet Router” and the 6lowpan sensors are labeled “IP sensor”. The IPv6 mobile ad hoc (manet) routers are labeled 500X Router where “X” is a alpha character distinguishing the various routes. One manet route is labeled Home Router. This is the router that remained in the lab connected to the Internet during mobile testing and acts as the anchor point for access to the manet via the Web.

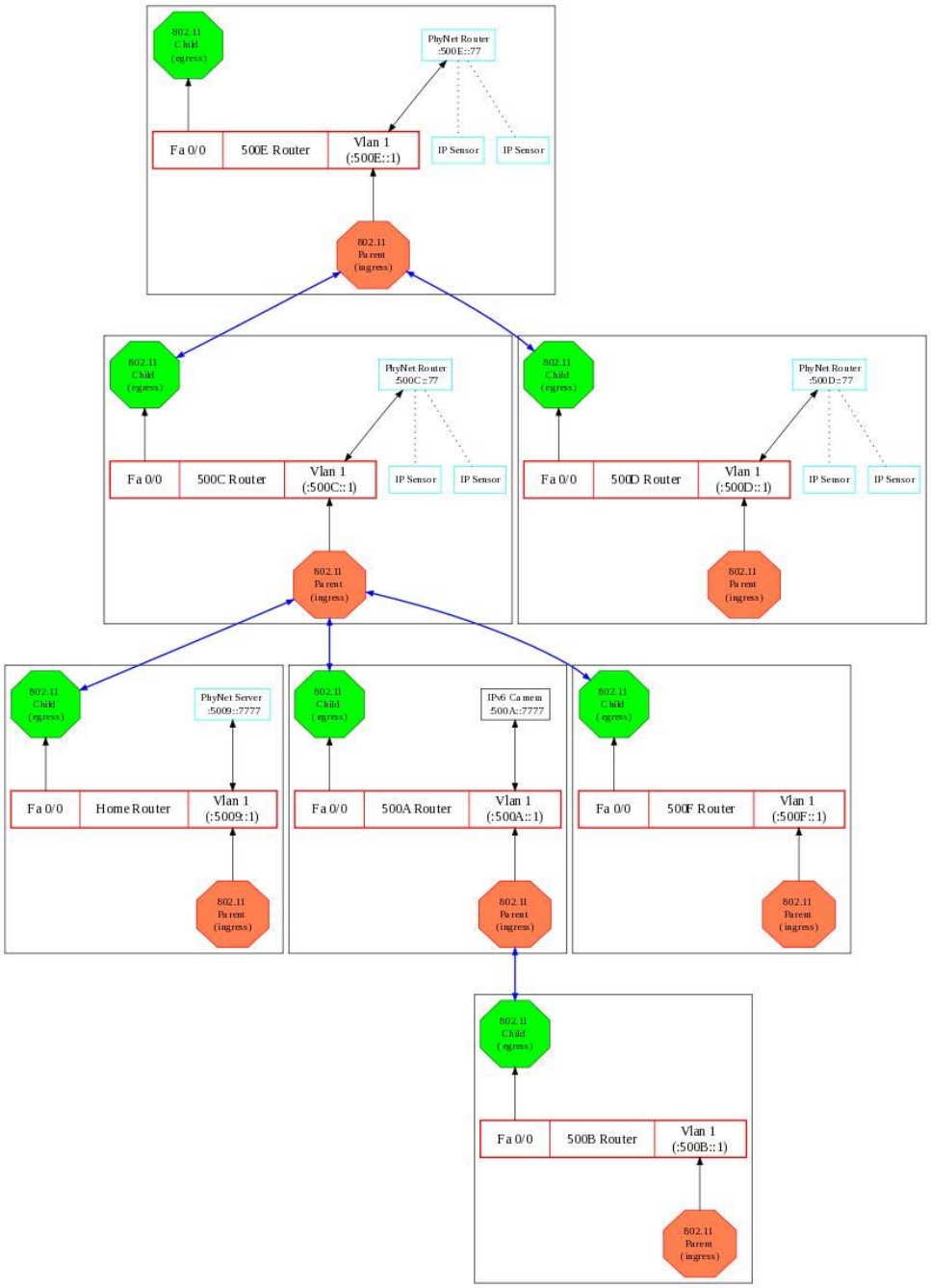

Figure 3: Mobile Network Topology 1

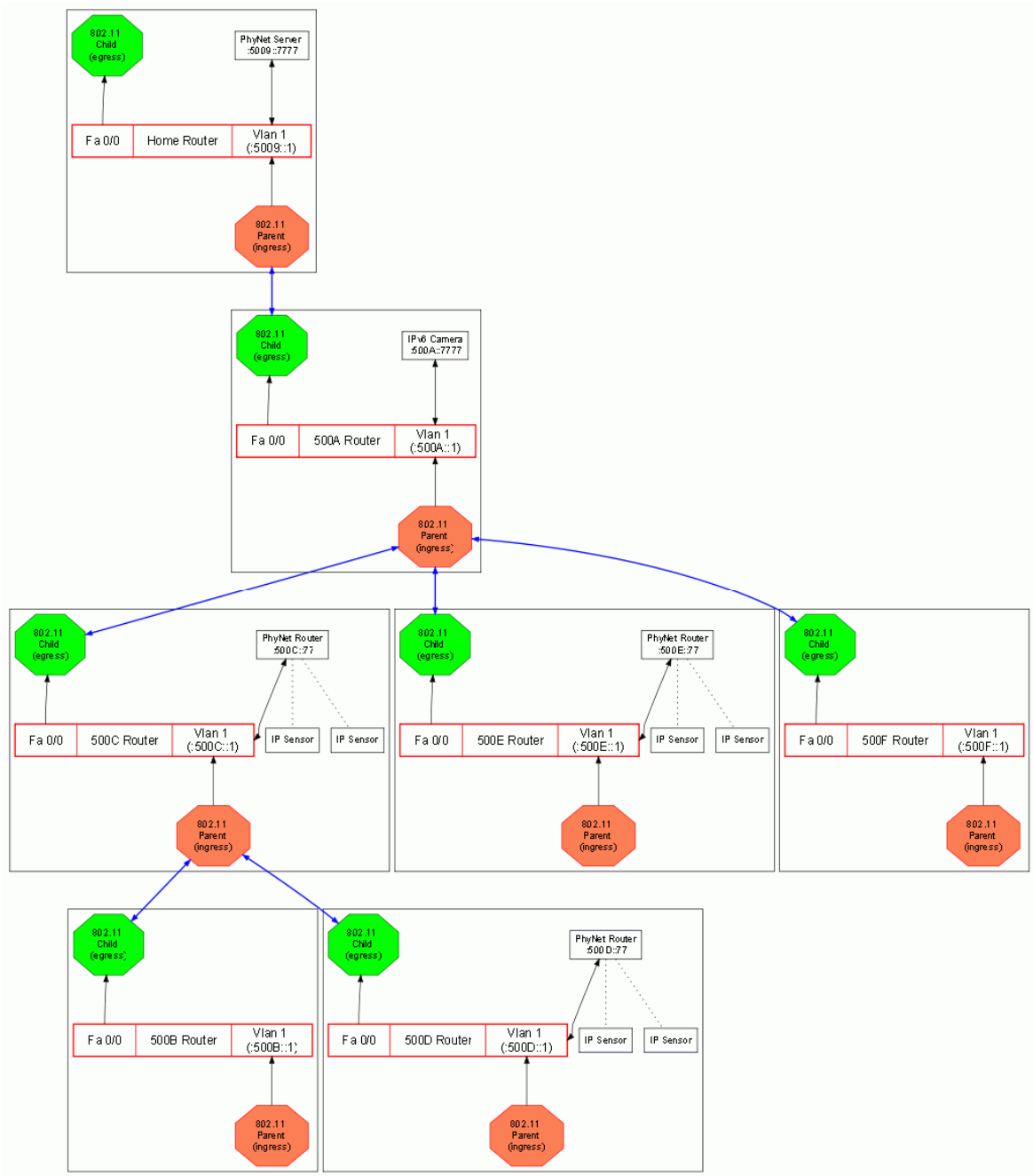

Figure 4: Mobile Network Topology 2

We placed GPS devices on two mobile networks to provide location information. That information was used to place the sensors on a map. In figure 18, the location of the van, mobile node 500C, is in the middle o f the map.

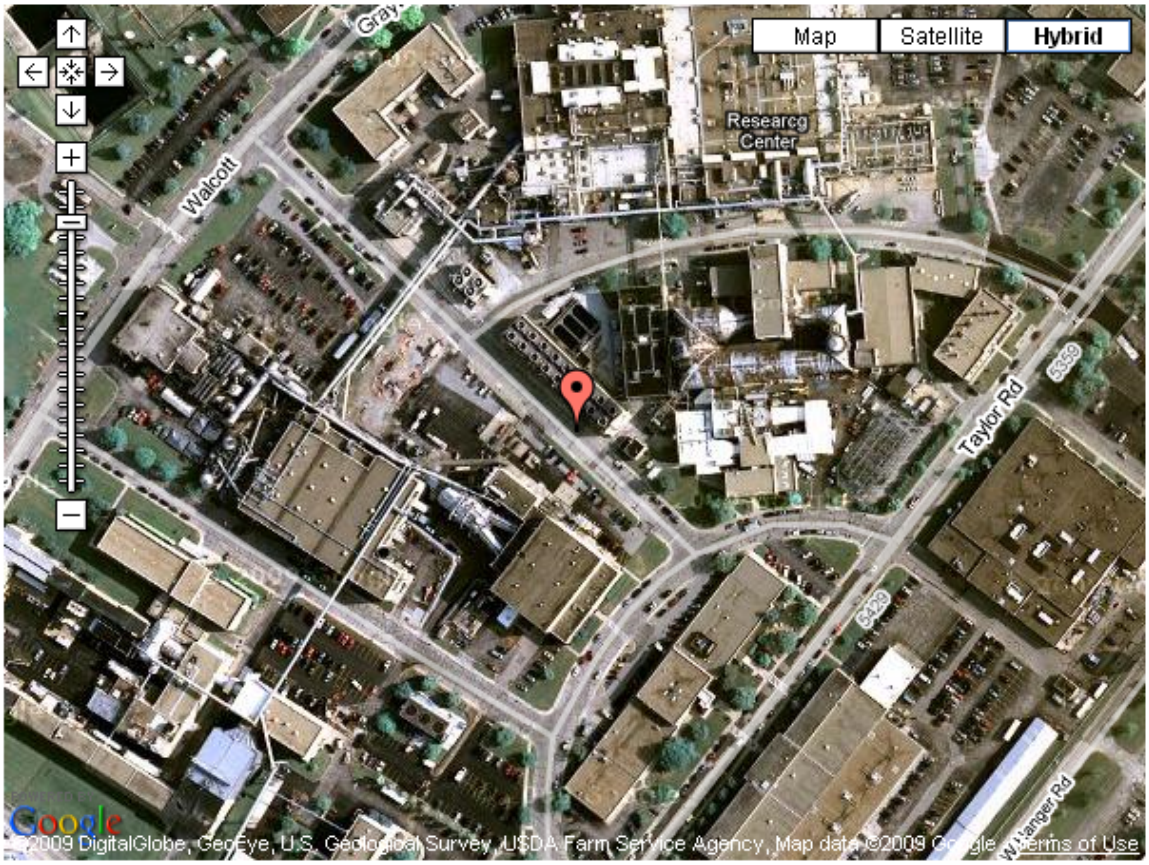

Figure 5: GPS location of 500C ACTS Van Node (IPv6)

Figure 19 shows a conceptual map of the location of the sensors as well as the actual readout of a series of 6lowpans sensors. These sensors are configured to monitor light, humidity, battery power and temperature.

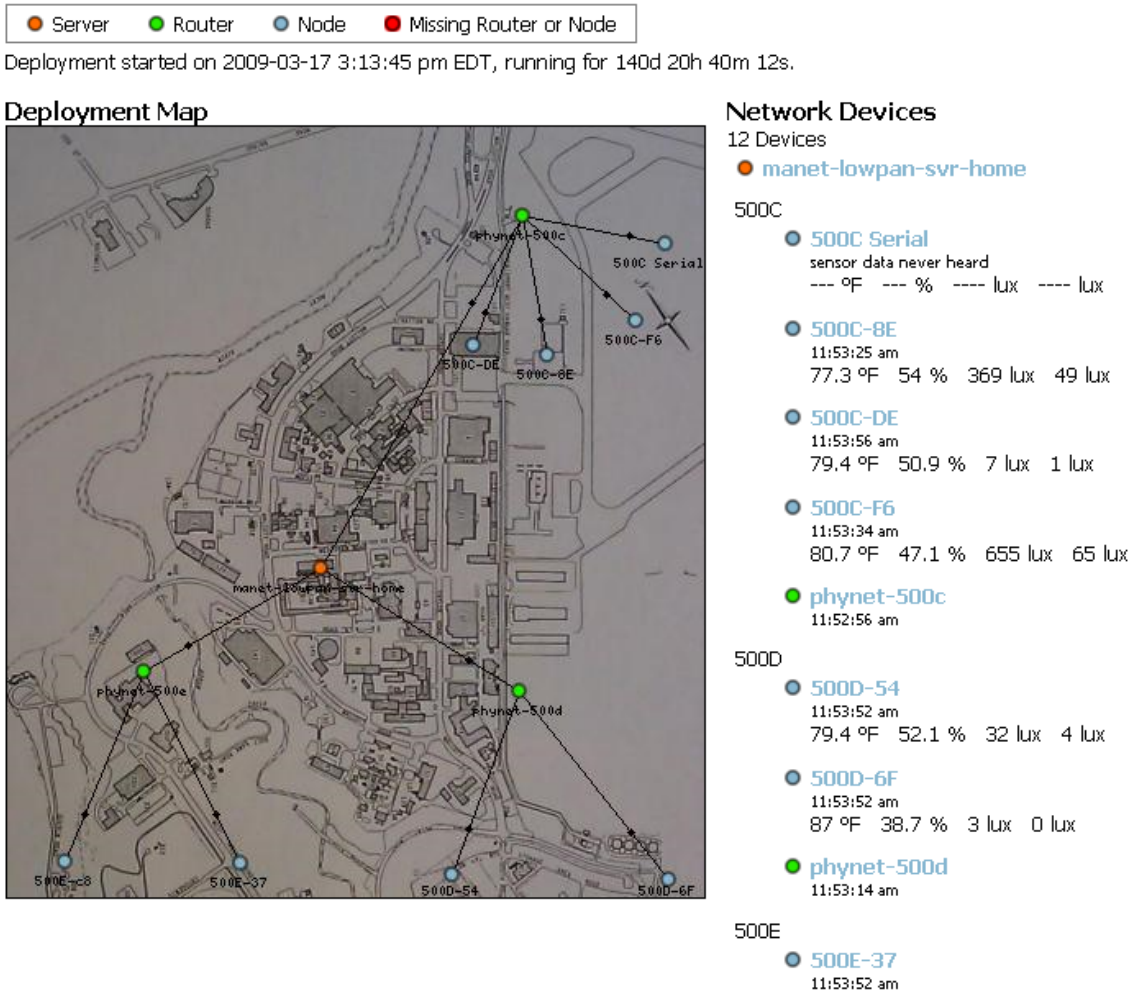

Figure 6: Conceptual Map of 6lowpan Sensors

Figure 20 shows the detail readout of a particular sensor. The sensor show is 500C-8E which was located on the mobile van. This sensor was located inside the cargo compartment of a moving van. Note the lights were off from 6:00 pm to about 9:00 am and the temperature increased soon after the sun came up at approximately 9:00 am.

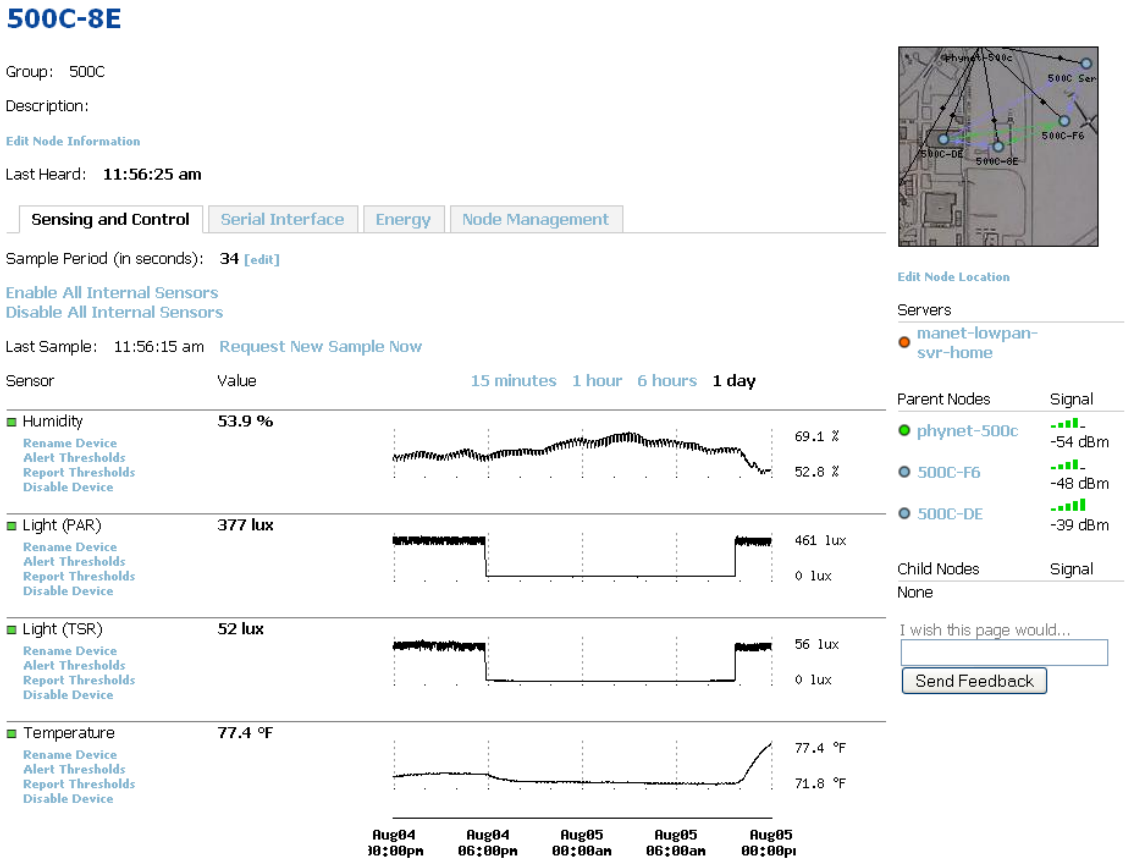

Figure 7: 6lowpan Sensor Monitoring

Figure 21 shows the output of the IPv6 Webcam attached to Mobile Node 500C, the mobile VAN. This Webcam was controlled using IPv6. The entire mobile sensor web and the 6lowpans sensors were all communicating via IPv6

Figure 8: Panasonic IPv6 WebCAM