Poster: Deploying a Mesh-based Command and Control Sensing System in a Disaster Area Maneuver

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Abstract

Wireless multi-hop networks meet the requirements of disaster area scenarios by their definition. Recently, different mesh and Wireless Sensor Network (WSN) testbeds were deployed. However, these deployments do not meet the specific characteristics of disaster area scenarios. Developing algorithms and protocols for public safety scenarios and deploying public safety networks is a huge challenge.

We have developed *BonnSens* a commercial off-the-shelf (COTS)-based prototype of a mesh-based command and control sensing system for public safety scenarios. In this poster, we present experiences as well as first measurement results from an on-site deployment in a disaster area maneuver. Overall, our goal is to see which approaches are applicable for public safety networks and where further specific challenges are.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design—*Wireless communication*

General Terms

Measurements, Experimentation, Reliability

Keywords

Sensing System, Command and Control, Disaster Area

1 BonnSens

BonnSens consists of a sensor data client application running on Android phones. Measurements from sensors like Global Positioning System (GPS), accelerometers, and magnetometers are transmitted adaptively to a server. At the server, sensor data fusion algorithms operate on the data to visualize tracks using a tracking GUI.

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2 Lessons Learned

We deployed a mesh backbone as well as portable, lightweight sensing nodes. To date, we have done field tests in four maneuvers. During these maneuvers, we had to learn several lessons that we will discuss now. By doing so, we will also describe challenges typical for public safety networks and systems.

Location information is nice but needs to be filtered and fused.

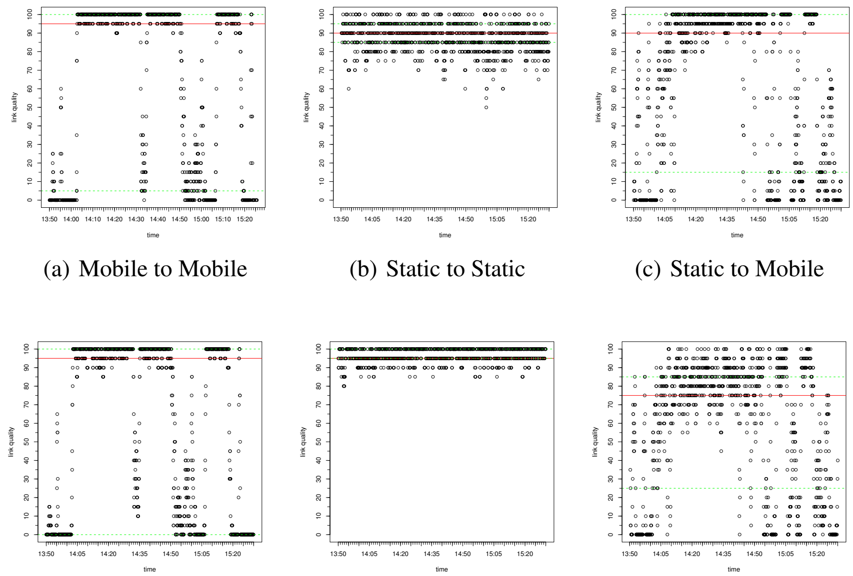
As portable, lightweight sensing nodes, smartphones are used in our system. Many smartphones on the market today have integrated sensors like GPS. Thus, these devices seem to be an ideal basis for the map based tracking part of our command and control system. However, just visualizing raw GPS positions of all lightweight nodes is not sufficient for disaster areas. An accuracy of 1m is requested. This accuracy is not reached on typical maneuver sites due to obstacles. Thus, the raw positions have to be filtered and fused. Using standard filters such as a Kalman filter in the system yields to new challenges such as Out-of-Sequence (OoS) measurements (cf. [3]). The filters need to be optimized for the usage in typical multi-hop networks.

The most important sensor data is the battery power of the devices.

For the measurements as well as for the units that want to use the command and control system, it is important that all devices do not run out of battery. If necessary, single batteries have to be exchanged. For doing so, it is important to know the nodes that have battery problems. Thus, we learned that the most important sensor data to be aware of during the deployment is the battery power of the devices deployed.

Prioritize the data - the data rate may be limited.

Some voice messages and sensor information transmitted may have higher importance than others. This becomes relevant especially when the data rate is limited due to sub-optimal signal propagation characteristics. Furthermore, when messages are transmitted as broadcasts on the link layer, the basic rate is used. This may lead to additional



(a) Mobile to Mobile (b) Static to Static (c) Static to Mobile

(d) Mobile to Mobile (e) Static to Static (f) Mobile to Static

Figure 1. Link quality measurements of selected links during one of the maneuvers over the time

rate limitation. Thus, data prioritization or, more general, communication and sensor management needs to be implemented. In our system, we implemented the Sensor Data Transmission and Management Protocol (STMP) [2] to take care of prioritization as well as communication and sensor management.

Do not expect approaches performing well in the lab or in a simulation will do the same in the field.

Especially in early deployments, it is important to save all data locally as well – just in case if there is a problem with the network (e.g., limited data rates). This also allows for an easier debugging. However, when relying on local logs, non-synchronized clocks may be a challenge afterwards.

Furthermore, approaches well-described in the literature and evaluated in simulations or labs, may not run very well in real deployments. For example, links may be extremely variable (cf. section 3) which yields suboptimal performance of some approaches.

3 Measurement Results

In several deployments, we encountered severe problems to realize a stable, spontaneously deployable, adaptive routing. Finally, it turned out that one of the main challenges were extremely variable links. Figure 1 shows the link quality of selected links during one of the maneuvers.

One can see that all links show some variability. The links visualized in figures 1(a) and 1(d) are the links between two mobile nodes. There are periods in which the link qualities are very good alternating with very poor link quality periods. This effect is induced by the specific movements in a disaster area scenario. Figures 1(b) and 1(e) visualize the links between two static mesh routers while figures 1(c) and 1(f) visualize the links between a static mesh router and a mobile node. Both link pairs show link asymmetries induced by the specific environment. Ignoring asymmetric links, as some routing protocols do, will yield clustering effects and may result in a partitioned network.

Of course, phenomena like link asymmetry and gray zones have been seen in other measurements as well (e.g., [1, 4]). Nevertheless, we think that the scenarios and movements lead to specific effects such as alternating links and clustering. This may lead to suboptimal performance of standard approaches in public safety scenarios.

4 Conclusion and Future Work

We have developed *BonnSens* a COTS-based prototype of a mesh-based command and control sensing system for public safety scenarios. We have performed several on-site deployment tests in disaster area maneuvers and learned our lessons. Especially links tend to be special due to the specific settings and movements. Next, we will perform further deployments to evaluate new, cross-layer approaches to deal with the specific link properties.

5 References

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