THE OPTIMIZATION GOALS AND FIGURE OF MERIT.

- For all these scenarios and application types, different forms of networking solutions can be found.
- The challenging question is how to optimize a network, how to compare these solutions, how to decide which approach better supports a given application, and how to turn relatively imprecise optimization goals into measurable figures of merit?

1. Quality of service

- WSNs differ from other conventional communication networks mainly in the type of service they offer. These networks essentially only move bits from one place to another.
- Possibly, additional requirements about the offered Quality of Service (QoS) are made, especially in the context of multimedia applications.
- Such QoS can be regarded as a low-level, networking-device-observable attribute - bandwidth, delay, jitter, packet loss rate - or as a high-level, user-observable, so-called subjective attribute like the perceived quality of a voice communication or a video transmission.
- But just like in traditional networks, high-level QoS attributes in WSN highly depend on the application. Some generic possibilities are:

Event detection/reporting probability

- What is the probability that an event that actually occurred is not detected or, more precisely, not reported to an information sink that is interested in such an event? For example, not reporting a fire alarm to a surveillance station would be a severe shortcoming.
- Clearly, this probability can depend on/be traded off against the overhead spent in setting up structures in the network that support the reporting of such an event (e.g. routing tables) or against the run-time overhead (e.g. sampling frequencies).

Event classification error

- If events are not only to be detected but also to be classified, the error in classification must be small.

Event detection delay

- The delay between detecting an event and reporting it to any/all interested sinks.

Missing reports

- In applications that require periodic reporting, the probability of undelivered reports should be small.

Approximation accuracy

- For function approximation applications (e.g. approximating the temperature as a function of location for a given area), what is the average/maximum absolute or relative error with respect to the actual function? Similarly, for edge detection applications, what is the accuracy of edge descriptions; are some missed at all?

Tracking accuracy

- Tracking applications must not miss an object to be tracked, the reported position should be as close to the real position as possible, and the error should be small.

2 Energy efficiency

- Energy is a precious resource in WSN that energy efficiency should therefore make an evident optimization goal.
- It is clear that with an arbitrary amount of energy; most of the QoS metrics can be increased.
- Hence, putting the delivered QoS and the energy required to do so into perspective should give a first, reasonable understanding of the term energy efficiency.
- The most commonly considered aspects are:

Energy per correctly received bit

- How much energy, counting all sources of energy consumption at all possible intermediate hops, is spent on average to transport one bit of information (payload) from the source to the destination? This is often a useful metric for periodic monitoring applications.

Energy per reported (unique) event

- Similarly, what is the average energy spent to report one event? Since the same event is sometimes reported from various sources, it is usual to normalize this metric to only the unique events.

Delay/energy trade-offs

- Some applications can increase energy investment for a speedy reporting of such events. Here, the trade-off between delay and energy overhead is interesting.

Network lifetime

- The time for which the network is operational or, put another way, the time during which it is able to fulfill its tasks. It is not quite clear, however, when this time ends.

Time to first node death

- When does the first node in the network run out of energy or fail and stop operating?

Network half-life

- When have 50% of the nodes run out of energy and stopped operating. Any other fixed percentile is applicable as well.

Time to partition

- When the first partition of the network in two (or more) disconnected parts occur.
- This can be as early as the death of the first node or occur very late if the network topology is robust.

Time to loss of coverage

- A possible figure of merit is thus the time when for the first time any spot in the deployment region is no longer covered by any node's observations.

Time to failure of first event notification

- A network partition can be seen as irrelevant if the unreachable part of the network does not want to report any events in the first place.
- This can be due to an event not being noticed because the responsible sensor is dead or because a partition between source and sink has occurred.

3 Scalability

- The ability to maintain performance characteristics irrespective of the size of the network is referred to as scalability.

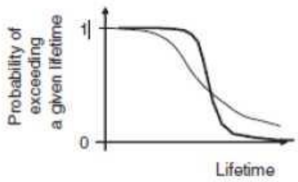

Figure 3.6 Two probability curves of a node exceeding a given lifetime – the dotted curve trades off better minimal lifetime against reduced maximum lifetime

4 Robustness

- WSN should exhibit an appropriate robustness.
- They should not fail just because a limited number of nodes run out of energy, or because their environment changes, these failures have to be compensated by finding other routes.