# OPTIMAL WIRELESS SENSORS LOCATION FOR WIDESPREAD STRUCTURES MONITORING

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## 1. Formulation

Structures and environmental monitoring are important factors of proper work of intelligent structures and they have a strong effect on their safety. Traditionally, the structure's state was registered by human observers or remote measurement devices connected directly to event recorders. Modern telecommunication technology enables application of wireless sensor networks [1] for monitoring, making possible extremely increase spatial density and temporal frequency of observations. Such sensors are both measurement devices and a communication network nodes broadcasting their own signal and retransmitting signals obtained from neighbors. Thus, they constitute a self-organizing P2P network that collects measurements and transmits them to managing or analytic centre.

## 2. Measurement conditions constraints

Design of a monitoring system for a structure requires adequate selection of sensor's locations. Since usually the number of sensors is fixed, equal $n$, their locations must be optimally selected to obtain the best observation result for such limited resources. Depending on a concrete task, system designers use different optimality criteria for the sensors' locations [2]. For instance, they can be uniform distribution of sensors over the structure, non-overlapping information criterion, highest sensitivity criterion, minimal correlation of measurements criterion, etc. These criteria usually take into account properties of a mechanical phenomenon measured and usability of the received data for a certain engineering task, e.g. structure control. However, in modern wireless sensors networks more criteria, mainly following from wireless communication conditions must be taken into account [3]. Such criteria are usually independent of structural optimality criteria, what force the monitoring system designers to use multiple criteria optimization [4] to select best locations for sensors at structural elements or in the environment.

The purpose of this paper is to propose a procedure that can optimally design wireless sensor networks for widespread structures monitoring in uncertain environmental conditions.

## 3. Topologies and communication conditions constraints

Optimal deployment of wireless sensors should first of all ensure the best communication efficiency possible as well as appropriate wear and failure resistance. The basic type of wireless sensor networks has a homogenous structure. Due to the requirements of a monitored structure, a network with (privileged) supernodes and (auxiliary) communication nodes, or a combination of both, can be applied.

The main criteria to be taken into account with the application of wireless technology are the criteria that have an effect on the lifespan of a sensor network such as the criterion of the minimum power consumption for data transmission, distance minimization to the node collecting data from the paths, optimal data transmission path criterion, load minimization measured, for example, by the

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mean traffic value carried by the node (the necessity to use network resources evenly). The optimal deployment of nodes should also take into consideration the requirement of alternative path availability in case of a failure (each node has to have more than just one neighbor), the requirement of avoiding communication obstacles and also cost-effectiveness, to this extent limiting the number of sensors, and so on.

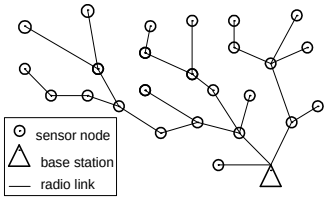


Fig.1. Homogenous network

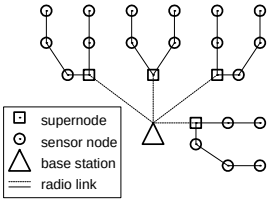


Fig.2. Network with supernodes

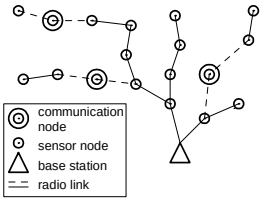


Fig.3. Network with communication nodes

Depending on the applied topology, these criteria have varied significance. For example, in a supernode network it is possible to invalidate the criterion of the even use of resources since the most loaded nodes can be replaced by supernodes, or the application of communication nodes can significantly mitigate the criterion for avoiding terrain obstacles, etc.

## 4. Criteria of optimality

The paper proposes a phased-in approach (in three stages) to problem formulation for optimization of the deployment of nodes of wireless sensor network for widespread structures monitoring. As the result of the first level of calculation a space of available solutions due to the quality of measurements criterion (mechanical) depending on the required measurement objective emerges. The second stage of the optimization effects in the establishment of the number of measure nodes with the criteria of the installation costs and replacement of each of the nodes in case of its failure taken into consideration. The third stage of the analysis is to optimize the deployment of sensors with a defined number of nodes with the maximum life-span of the network criterion taken into consideration, i.e. with the aim of the minimization of the distance of routes and avoiding the necessity of overloading of individual nodes.

The purpose of the performed analysis is to determine the acceptable locations of nodes of the wireless sensor network and then to decide on the preferred locations of nodes from the set of non-dominated solutions.

## 5. References

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