REPUTATION AS OPTIMALITY MEASURE IN WIRELESS SENSORS NETWORKS (WSN)-BASED MONITORING SYSTEMS

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1. Wireless Sensors Networks

Many solutions that wireless technology offers for practical engineering problems are based on Wireless Sensors Networks (WSN). These are networks consisting of small devices, usually autonomously controlled and with their own energy resources, equipped with different kinds of detectors. These devices with measuring detectors play a role of nodes of the network. Except of a measuring function, nodes also perform data processing and a communication function. WSN are useful for constructing efficient and cost-effective measuring and diagnostic systems. A module-based structure of a WSN makes it possible to connect to as a measuring device many different sensing elements, both analogue and digital. This, in turn, makes WSNs a cheap and flexible measuring tool. Moreover, since WSNs in a communication layer work as P2P or ad-hoc networks, they have adaptive capabilities in diversified working conditions and are capable of transmitting and forwarding data over large distances. Weak points of WSNs' nodes are their limited communication and calculations possibilities and limited energy storage. Therefore, for proper functioning, they need optimized location of nodes of a WSN [1] and special communication protocols [2].

2. Reputation

Two concepts start playing an important role in modern applications of probability: trust and reputation. We can define *trust* as probability that a party will behave according to our expectation, honestly, in a specific situation. In this context, reputation can be defined as conditional probability of honest behaviour of a party where the condition is an available experience accumulated from past behaviour of the party. Such a definition can be generalized (e.g., to a vector-valued form, reflecting several aspects of reputation), but its probabilistic origin remains valid.

3. Reputation systems

To estimate reputation of a party or a service, we must define a reputation system, which enables collecting, exchanging, and processing appropriate information. We must also define a reputation measure, which lets us assigning reputation scores (e.g., probabilities) to events registered by the reputation systems. Existing reputation systems can be classified according to their functional properties (e.g., objective/subjective, centralized/distributed) and according to mathematical methods applied (probabilistic, fuzzy logic-based, deterministic), see [3].

Reputation systems found their application in practice, especially in web services, e.g., electronic auctions, e-shops, social networks, etc. There are also attempts to apply a reputation system for validating routing nodes in ad-hoc networks [4]. Such a tool was very useful for optimization of communication in Mobile Ad-hoc Networks under random disturbances.

4. Optimal sensors' location

Permanent structure's monitoring enables immediate and effective detection of its failure or its anomalous behaviour. It is especially important for proper functioning of intelligent structures and mechanisms and for their safety. In the literature one can find methods of optimization of sensors'

location using different criteria [5]. One of most often used criterion comes from information theory [6]; it is extensively used in problems of practical interest [7], [8], [9].

Application of WSNs for environmental and structural monitoring not only makes it possible permanent observation of working structures but also increases functionality of the monitoring system and decreases its overall cost. However, designing WSN-based monitoring system, one must take into account additionally (except of usual engineering constraints) specific restrictions connected with low energy broadcasting in WSN. Thus, in such a case the optimal location of sensors should take into account, both, conditions connected with structure's behaviour (finding the most "informative" measurement points) and environmental conditions determined by random disturbances of transmission of a signal measured, depending on external electromagnetic fields and structural barriers, see [10].

Thus, optimization of sensors' locations in a WSN for structural monitoring needs taking into account criteria of quite different nature. Firstly, we must optimize communication in an ad-hoc network (a quality of transmission, the network performance and lifetime of the sensors) with an additional constraint of a limited communication range of sensors. Secondly, we should choose such locations of sensors that give best measurements for specific engineering purposes. A natural solution seems to be application of a multi-criteria optimization system, which unifies very different measures of quality to a single decision criterion. The proposed application of a reputation system dedicated to the WSN dodges the problem of different optimality criteria for communication and for measurements. In these both cases, we measure quality with probability of certain events, so consolidation of the obtained results can be made on grounds of the probability theory. Moreover, such an approach makes it possible to construct an adaptive optimization system consistent to the reputation-based optimality criterion. Statistical data collected during measurements are a good source for reputation estimations of all events required to choose optimal locations of sensors in the WSN designed for most structural and environmental engineering problems.

5. References

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