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Wireless LANs

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| Self-Growing Use Cases requiring Fast Initial Link Setup |
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Abstract

This documents presents use cases for TGai related to self-growing

# Introdution

The novel concept of purpose-driven, self-growing networking [3] addresses those challenges. A self-growing network coexists, collaborates or integrates—potentially in symbiosis—with collocated networks utilizing their service or geographical extend to augment network capacity, or operational constrains such as energy consumption. The self-growing process including network operation and management is realized by focused cognitive decision making controlling network and node reconfiguration. This function discovers if other networks or devices comprise cognitive, self-growing features. To reduce the time spend in this discovery, a fast link set-up is required.

This document presents use cases that will be enabled by cognitive engines providing self-growing, relying on fast link set up.

Due to the commercial relevance of 802.11, the provisioning of fast link set-up for 802.11 is considered a key enabler for a highly efficient application of the self-growing paradigm to 802.11.

# Self growing networking

## Energy-aware end-to-end delay optimization.

Sensor nodes are deployed in a given environment partially covered by a second type of network, e.g. IEEE 802.11 WLAN. The sensor nodes are equipped with a reconfigurable radio unit; they share the communication band (e.g. 2.4 GHz band) with the WLAN but use a sensor network specific MAC protocol optimized for low energy consumption in order to achieve a long lifetime of the sensor network.

During their lifetime of the sensor network, a change in its purpose occurs: in addition to existing functionality, sensor nodes have to report on delay sensitive data to a data sink. For such, the sensor network has to be reconfigured: the routing of messages through the sensor node (multi-hop communication) and the sleep cycle of the sensor nodes has to be adjusted to meet the delay constraints. As a result, the purpose change is achieved but the network’s lifetime is degraded. A cognitive decision entity within the network uses this information to evaluate if a potential synergy of the partially deployed WLAN network with the sensor network can enable the new purpose at better energy cost. Integrating both networks enables additional routes from the sensor to the data sink. Those routes may have different properties in terms of delay. In order to use those now routes to forward delay-sensitve information via the WLAN, sensor nodes have to reconfigure their radio interface to using the 802.11 MAC, find available 802.11 APs, quickly associate to one AP for data offloading, and return to operation using the sensor network specific MAC to act as a relay for those sensor nodes not within coverage of an AP.

 Link-Attempt Rate: low – medium (less than 50 nodes)

 Media-Load: low (less than 10%)

 Coverage Interval: low (infinity; nodes reside within the BSS’s coverage)

 Link Setup Time: high (less than 100ms)

## Purpose-driven network reconfiguration during an emergency situation.

Sensor nodes forming an ad-hoc network are deployed in a given environment partially covered by a second type of network providing centralized, single-hop backbone access, e.g. IEEE 802.11 WLAN.

Both networks had gone through the self-growing phase having resulted in an integrated, symbiotic network under the control of cognitive decision entities: Selected sensor nodes act as gateways of the sensor network to the WLAN in order to reduce the number of hops a message has to travel within the sensor network.

Under normal operation, the sensor network provides sensing information (e.g. temperature in various locations of a building) at low duty cycles; the network is optimized for long network lifetime accepting higher delays in the acquisition of sensing information.

An incident situation occurs (e.g. a fire in parts of a building). As a result, the existing sensor node infrastructure is partially disrupted. Also, as a result of the incident situation, the metric driving the network configuration changes long lifetime of the network is less important. Instead, each sensor node tries to establish the shortest possible link to the Internet and tries to offload its sensing information as quickly as possible (as its destruction might be imminent). It therefore reconfigures its radio, and searches for available WLAN BSSs in order to establish a link as quickly as possible with appropriate APs.

Additionally, the cognitive decision engine controlling the network reconfiguration and self-growing process of the sensor and WLAN network might detect that sensor nodes are located in an are where WLAN coverage is (no longer) given. As a result, sensor nodes are reconfigured to permanently use the 802.11 MAC in order to act as a meshed network re-establishing 802.11-based coverage. Mobile devices of users within the incident area have to quickly discover those newly available “mesh APs” and to quickly establish a link with them.

 Link-Attempt Rate: high (more than 50)

 Media-Load: medium to high (more than 10%)

 Coverage Interval: low to medium (more than 1 second)

 Link Setup Time: high (less than 100ms)

## Cognitive Coexistence and self-growing for white space operation

This use cases focuses on a locally deployed access point operating in white spaces in order to form a WLAN providing access to a small (company) network. During its lifetime, the capabilities of the device dynamically grow from an operation without coexistence to a fully coexisting operation mode with other white space devices deployed in the surrounding. In a second phase, the self-growing of the network, the purpose of the deployed network elements grows from only supporting nomadic mobility to additionally supporting seamless mobility for mobile users.

In particular, this is achieved in various ways: A cognitive decision engine achieves separation in (used) spectrum by intelligently assigning valid spectrum portfolios to devices. Hereby, the engine learns about the requirements of each device and intelligently considers a dynamic adaptation of assigned spectrum per node/network. This allows each network to adapt its purpose according to users’ needs (e.g. adding low latency low bandwidth communication for surveillance purposes to existing high bandwidth but long delay services). At the same time, the cognitive engine learns about devices having coexistence issues (and hence are candidates for being in communication range of each other). Hence, the rules of the decision engine at each device are updated to allow a technology specific detection of other (heterogeneous) devices in communication range. Where applicable, the cognitive decision engines may decide to trigger a reconfiguration of devices enabling direct communication among existing networks. This self-growing phase enables additional services. First, direct (or multi-hop) wireless links among deployed devices allow to distribute among several low-bandwidth wired connections (e.g. DSL lines) the traffic going to and coming-in from the Internet. This enables high-throughput communication and allows fully exploiting the capacity of the wireless communication medium. Second, existing homogeneous network elements originally not in the communication range of each other and support nomadic mobility of the end-user. The self-growing process integrates several heterogeneous network elements into one access network providing continuous radio coverage to the end-user thereby enabling seamless mobile usage.

For the integration of 802.11-based networks in this self-growing process, devices have to be capable to act as a 802.11 STA in order to find 802.11 networks in their vincinity and to quickly establish a link with them to query for cognitive, self-growing capabilities via application layer services. As such link establishment might interrupt ongoing real-time communication using other technologies (due to a possible re-use of a single, reconfigurable transceiver chain), link set-up has to be conducted as quickly as possible.

 Link-Attempt Rate: low (less than 10)

 Media-Load: varies from low to high, depending on the usage of the network

 Coverage Interval: low (more than 10 seconds)

 Link Setup Time: high (less than 100ms)

# References:

[1] CONSERN Deliverable D1.1 – Scenarios, Use Cases, and System Requirements. September 2010.

[2] B. Bochow and M. Emmelmann: Purpose-driven, Self-growing Networks – a framework for enabling cognition in systems of systems. GreeNET Workshop at VTC Spring 2011.

[3] B. Bochow, M. Schuster, L. Thiem, and J. Tiemann, “A novel system paradigm for self growing wireless networks,” 2010. [Online]. Available: http://publica.fraunhofer.de/documents/N-132320.html