

SOLDER Newsletter

November 2015

Aggregation of Heterogeneous Dispersed Bands

The main scope of SOLDER project is to extend the carrier aggregation concept, defined in 4G and foreseen to become a building block of the beyond 4G communication system (known as 5G) vision. The main target areas of aggregation are considered as Heterogeneous Networks (HetNets) and heterogeneous RATs (h-RATs), and heterogeneous spectrum types. This project is targeting the following objectives:

1. To support aggregation of multiple carriers, intra- and/or inter-band in order to achieve flexibility in terms of band and bandwidth supported. This includes the consideration of different and pioneering spectrum opportunity types.
2. To devise advanced aggregation algorithms for a multi-mode transmitter and receiver over non-continuous and dispersed bands in order to achieve highest spectral efficiency and aggregated capacity.
3. To develop means to improve the CR transmitter energy efficiency and power consumption thanks to fully digital solutions.
4. Develop radio resource management (RRM) techniques for heterogeneous networks on heterogeneous spectrum types, allowing exploitation of the full potential of heterogeneous carriers.
5. To explore appropriate decision making approaches by applying machine learning to enable a user to learn how to appropriately response to spectrum dynamics and context information, so as to maximize its performance and maintain quality of service (QoS).

Architecture

WP2 in SOLDER has completed its scheduled work in the time that this Newsletter is being prepared. WP2 has produced results considering the state-of-the-art for aggregation, the definition of scenarios and use cases for aggregation, and analysis of component-level and system-level requirements for those scenarios and use cases. In addition to detailed analysis, it has produced a succinct summary of the work that the project is doing in the form of 8 specified use cases and scenarios, each with all relevant characteristics specified as a source of reference for the project. More recently, supplementing its key work, it has defined a general architecture to support aggregation which is heavily based on management, in view of management being a key aspect that can be addressed among different systems—even if it is not feasible to integrate them for aggregation purposes (e.g., if they operate in distant frequency bands). It has specialized this to a specific LTE-related architecture.

It is intended for this architecture to be a supporting/complementary element for some of the use cases and scenarios that SOLDER is considering – particularly those that ag-

gregate different types of systems in different bands. WP2 drives the work in WP3 dealing with the innovative design solutions and it's also linked with the proof of concepts within WP4. WP2 and WP3 results are going to be presented in a collaborative publication. Moreover, WP2 is considered the ground for contribution to standardization.

Innovative Design Solutions

SOLDER research leads to particular innovative design solutions on carrier aggregation for heterogeneous networks and technologies. This work is carried out within WP3 and an indicative list with technical details from recent developments are given below:

- A dynamic CA for beyond LTE-A system employing cognitive radio principles in heterogeneous networks and technologies is going to be implemented for 5G system.
- Implementation of scheduling to support Carrier Aggregation functionality in commercial products and simulators is being provided to deal with multiple component carriers scheduling. This leads to introducing new features in LTE MAC Lab.
- The LTE with Unlicensed bands aggregation based on the LAA (Licensed Assisted Access) working item of 3GPP is being analyzed and simulated Cognitive radio application, e.g. listen before talk, carrier selection etc. is being carried out.
- Contributions on cognitive network management architectures supporting aggregation, and particularly the linking of that with geolocation databases.
 - Also related to this effort, some seminal work on aggregation in or involving TV white spaces, including implementation of white space devices at KCL and Eurecom and usage of that knowledge to assist in developing the geolocation database-based management architecture around that.

Proofs of Concepts

SOLDER is going to provide three main proof of concepts (PoCs) that will benchmark the implementation of the aggregation of heterogeneous bands within LTE and non LTE systems. WP4 is dealing with the system integration and experimental results, wherein the three PoCs are listed in the table below. All members are developing several building blocks to their HW platforms and simulators, wherein the integration will be accomplished next year. However, a few features will be demonstrated in this year to the 2nd year review. Collaboration among partners will provide more demonstration capabilities, e.g. IS-Wireless' scheduler is being implemented on Open Air Interface of Eurecom, and Thales' FBMC is being implemented on Cognitive Radio Interface of Industrial Systems Institute.

Table-1: SOLDER PoCs names, scenarios assumed and platforms used.

PoC #	PoC Name	Scenario	Platform
PoC 1a	Aggregation of TV White Spaces and WiFi Bands for augmented broadcast	Aggregation of heterogeneous spectrum types	Kings College London and Eurecom devices
PoC 1b	Aggregation of LTE in licensed and unlicensed bands		Industrial Systems Institute Cognitive Radio Platform
PoC 2	Energy efficient transmission technologies	5G Waveforms	Eurecom ExpressMIMO2 platform
PoC 3a	LTE-A inter-band carrier aggregation in homogeneous networks	LTE Carrier Aggregation	Eurecom Open Air Interface with IS-Wireless scheduling algorithm and Sequans UE
PoC 3b	Dynamic cognitive CA in HetNets: LTE-A and beyond		Industrial Systems Institute Cognitive Radio Platform

An important milestone in the development of the carrier aggregation features of OpenAirInterface was reached in October 2015. In this video (<https://youtu.be/xoDMZ5Vy1Ew>) we show a first demonstration of this feature using a test user equipment from Sequans. The setup is inter-band carrier aggregation of two 5MHz channels in bands 4 and 13.

Dissemination

SOLDER led the organization of the ISWCS 2015 CRAFT Workshop. Some SOLDER project results and presentations were given during this workshop, on the 25th of August 2015 in Brussels, Belgium. The following picture is of the workshop and a subset of the attendees.



A large number of high-profile presentation and paper publications have been achieved by SOLDER participants, many of the presentations are invited by key organizations—including governmental initiatives and regulators, among others. Moreover, paper publications and key presentations of the project are listed in the SOLDER website (<http://www.ict-solder.eu>).

Coming events

- November 2015, SOLDER will be represented at a 5G standards meeting organized by the IEEE ComSoc in, taking place in the Google Headquarters of Silicon Valley. This is a repeat invitation based on prior input in April 2015 at the IEEE Headquarters near New York, which also included inputs that were partially linked to SOLDER.
- December 2015, GLOBECOM, Tutorial on System-level modelling of HetNets, Carrier Aggregation and Scheduling in MATLAB, IS-Wireless.
- January 2016: SOLDER members are working towards the first demonstration in Brussels of the proofs of concepts mentioned above.