

# Abstract of project ANR SARAH

## *Asynchronous Distributed Services for Mobile Ad Hoc Networks*

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The objective of project SARAH (Asynchronous Distributed Services for Mobile Ad Hoc Networks) was to investigate the problems posed by disconnected mobile ad hoc networks, and their ability to support the transfer of data and the deployment of distributed services.

Mobile ad hoc networks are composed of CMTs (Communicating Mobile Terminals) that can communicate directly with one another, without resorting to fixed relays, thanks to direct low-range radio transmissions. These CMTs can for example be laptops or smartphones carried by mobile users. They can also be systems embedded in vehicles or robots, sensors attached to wild animals, etc.

Many communication protocols have been developed during the last two decades for transporting data in mobile ad hoc networks, but most of these protocols can operate only in dense and sufficiently connected networks, that is, networks where a path is always available to ensure communication between any pair of CMTs, possibly via a number of intermediary CMTs.

Yet, not every mobile ad hoc network presents such favorable properties of density and connectivity. Actually, in many cases, connectivity in a mobile ad hoc network is only partial or intermittent. In such disconnected networks, some CMTs may be only sporadically, if not never, in radio range of one another. Project SARAH explored means to allow communication and service provision in this kind of challenging environment. The project was divided in four complementary research themes that dealt respectively with the problems inherent to communication in disconnected mobile ad hoc networks, the support for distributed services in such networks, the securization of communication and services and, lastly, the techniques of simulation and formal analysis allowing the developed methods and tools to be validated. In the domain of communication, the effort was mainly focused on the design of communication protocols based on the principle of *Disruption-Tolerant Networking* (DTN), which, in the framework of mobile ad hoc networks, consists in exploiting the CMTs as information carriers when they move in the network. This communication mode permits the transfer of messages in a disconnected —or partitioned— network, CMTs ensuring the transport of messages between non-connected parts of the network. In compensation, it implies high latencies in transmissions, which are to be accounted for in the design of distributed services that must be adapted to the networks considered. The absence of any stable and persistent piece of equipment in the network also fosters the development of services that operate in a peer-to-peer mode rather than follow the traditional client-server paradigm. A service platform was developed along this line in project SARAH. Several experimental application services were implemented, targeting deployment environments as diverse as networks of laptops, sensor networks and military tactical networks. The simulation and the validation of the protocols designed during the project required the development of new tools capable of modeling networks of CMTs, of simulating their evolution over time, and of observing interactions between CMTs in the various possible scenarios. Lastly, the security issues raised by the scenarios in which any CMT may relay the messages sent by a peer (in the absence of any certification authority) were tackled. Solutions were proposed that rely either on smart cards or on the derivation of asymmetric cryptographic keys from users' identities.

The work described above has resulted in the publication of about forty scientific articles in journals and international conference proceedings. Most of these articles, together with the various software tools implemented during the project, are available on the project Web site<sup>1</sup>.

Project SARAH allowed the four involved laboratory-partners to acquire real skills in the domain of mobile ad hoc networks with partial and intermittent connectivity, and to make these skills acknowledged at an international level. Besides, the work initiated in project SARAH continues in the framework of new projects in which the four partners participate, at the national level (e.g. ANR project) as well as at the international level (e.g. European projects).

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<sup>1</sup><http://www-valoria.univ-ubs.fr/SARAH>