Triangular relationship

A characteristic feature of mobile communications is that subscribers operate in a network of base stations used to process all communications. Future mobile devices will additionally be able to exchange data without an intermediate base station if they are in close proximity to each other. A tester for this scenario must be able to simulate not only a base station but also a mobile device with corresponding functionality – a case for the R&S®CMW500.

With the advent of device-to-device functionality (D2D) in Release 12 of the 3GPP specification, proximity services (ProSe) are possible for the first time in the history of cellular mobile communications. ProSe is based on a direct data transfer between two UEs. The use of such services has to be authorized, i.e. covered by the subscriber's cell phone contract. Once this is in place, the need for the base station is eliminated and under certain circumstances the devices can be used like walkie-talkies. The motivation for D2D is twofold. The first is an emergency or major disaster situation. If the mobile network is unavailable due to a power failure or if the rescuees or rescuers do not have network coverage, for instance in a cellar, self-sufficient mobile devices are exceptionally helpful. The second application scenario relates to local broadcast services, namely unidirectional data transfer.

To be able to handle D2D, the mobile device (UE) must have the new LTE D2D interface, which is called a sidelink. The UE is expected to be able to communicate over distances up to 500 m over the sidelink. D2D as per Release 12 can be implemented in two different forms: sidelink direct discovery (for broadcast) and sidelink direct communication (for groupcast). Both are possible in FDD as well as TDD networks and use the resources for the UL LTE Uu interface, which are allocated to the sidelink for this purpose. Direct communication is reserved for safety-related applications (see below for more detail), but the direct discovery feature is also open to commercial applications. In documentation from technology suppliers and network operators, this feature is referred to as LTE Direct (Qualcomm) and LTE Radar (T-Mobile).

No ProSe usage without authorization

Irrespective of whether the user would like to use the direct discovery or direct communication service, the UE first determines if it is authorized. If the UE has network coverage, this is usually done via a network request. The UE uses existing DNS lookup procedures to find the responsible server (ProSe function) at the contracting company. If there is no network coverage, a UE can be pre-provisioned for ProSe services by having ProSe authorization stored on the SIM card or in the UE file system. Rohde&Schwarz offers the R&S®CMW-Z6 SIM card option to test this capability.

Direct discovery – efficient messaging with network support

Sidelink direct discovery is an extremely efficient method for broadcasting locally relevant information to other nearby receivers. For example, retail businesses can use this feature to advertise special promotions. The announcing UE periodically transmits the ProSe application code (PAC), a short 184-bit data telegram, over the sidelink air interface (see Fig. 1). The monitoring UE forwards the PAC to the network ProSe function, where it serves as an access key to the actual XML-based user information (ProSe ID). The ProSe function delivers this previously uploaded ProSe ID to the monitoring UE over the mobile network.

An announcing UE's ProSe application first requests a PAC, such as: "mcc123.mnc456.ProSeApp.Theatre.Tickets.Sales.Available.2", and forwards it together with the broadcast information to the provider. If the provider gives a green light (which depends on the current network load and other criteria), the mobile network operator (MNO) responds to the request by issuing a PAC that is intended for broadcasting.

The specific design of the whole process in actual networks has not yet been finalized. One of the open questions is how to ensure that the message reaches every LTE subscriber,

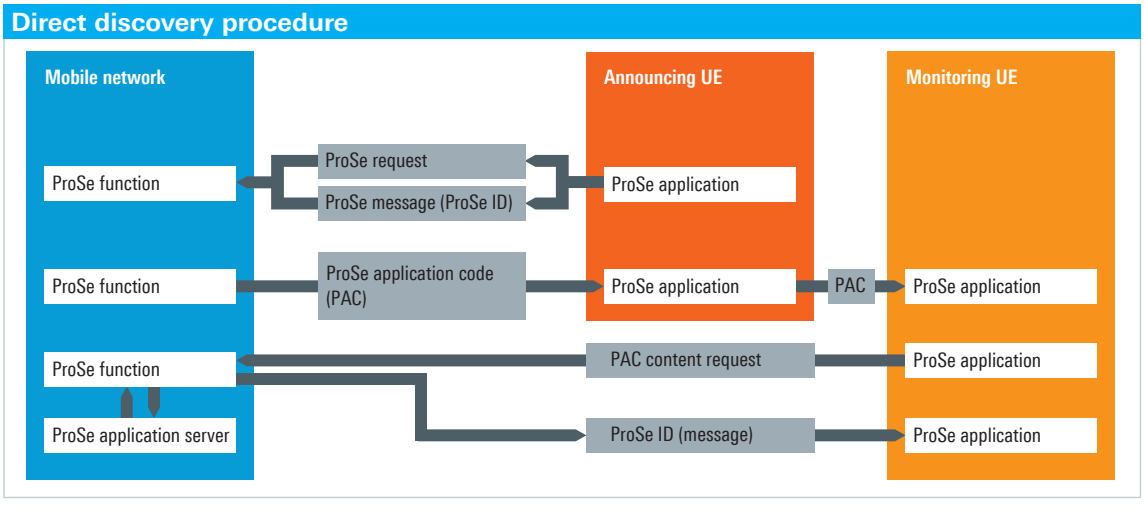

Fig. 1: Direct discovery means that a UE uses the network to broadcast locally relevant information to nearby receivers.

even when the transmitter and receiver are operating on different frequencies or are registered with different providers. 3GPP does not specify how two MNOs allow access to each other's ProSe function. The technical principles, however, are established in Release 12 so that the basic process can be simulated. The R&S®CMW500 with the Release 12 option can simulate this process.

Comprehensive ProSe tests with the R&S®CMW500

Fig. 2 shows the network and UE components involved in direct discovery. Fig. 3 illustrates this in greater detail from the perspective of the R&S®CMW500 with a connected UE. The tester has to provide measurement functions for the sidelink interface (PC5) and also be able to simulate the data traffic with the ProSe function via the logical PC3 interface (XML over http, routed via the LTE Uu air interface). The UE under test functions alternately as a direct discovery transmitter (announcing UE) and receiver (monitoring UE). The medium level API (MLAPI) for the R&S®CMW500 includes a DLL implementation of the network's ProSe function so that the ProSe protocol can be tested. UE development often takes place in teams working in parallel. These teams are dedicated either to the RAT or to the core network-related layers and interfaces. Since each team assumes that the other team's functionality will work, the direct discovery implementation on the R&S®CMW500 offers the possibility of circumventing the PC3 interface and carrying out tests even without implemented ProSe protocols by using test loop mode D in line with 3GPP TS 36.509.

According to the 3GPP specification, a UE that supports direct discovery must be able to receive up to 50 messages per channel (assuming a 20 MHz cell) within a single transmission time interval (TTI, 1 ms). To test this capability, the R&S®CMW500 generates up to 50 sidelink UEs in a specified frequency band. In addition (although this is not a firm requirement), a UE should also be able to monitor frequency bands of other local LTE networks in order to receive messages transmitted there. This situation is also covered by the R&S®CMW500. Two active sidelinks, each capable of receiving up to 50 messages per TTI, are set up in parallel on different frequencies.

Direct communication – modern IP communications for public safety and security

Public safety and security organizations have special communications requirements. In the past, they generally relied on customized (trunked) radiocommunications systems such as TETRA. The capability of commercially deployed technologies like LTE leave such systems far behind when it comes to performance. LTE direct communication solves the need for such features. It extends network communications by adding groupcast and push-to-talk direct mode functions that are typical of trunked radio systems. Voice, photos and high-resolution videos (which are not possible using traditional trunked radio systems with their low data rates) can easily be sent to members of a group. Each UE can be a member of any number of groups. Reserving radio resources and the security mechanisms for direct communication are described in detail in Rohde&Schwarz white papers [1, 2].

Direct discovery: network and UE components

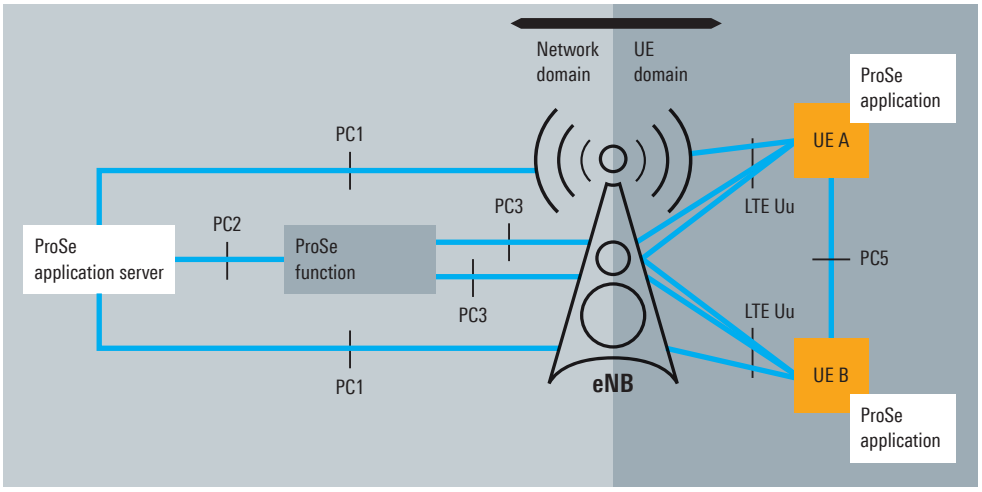

Fig. 2: Network resources and interfaces involved in ProSe.

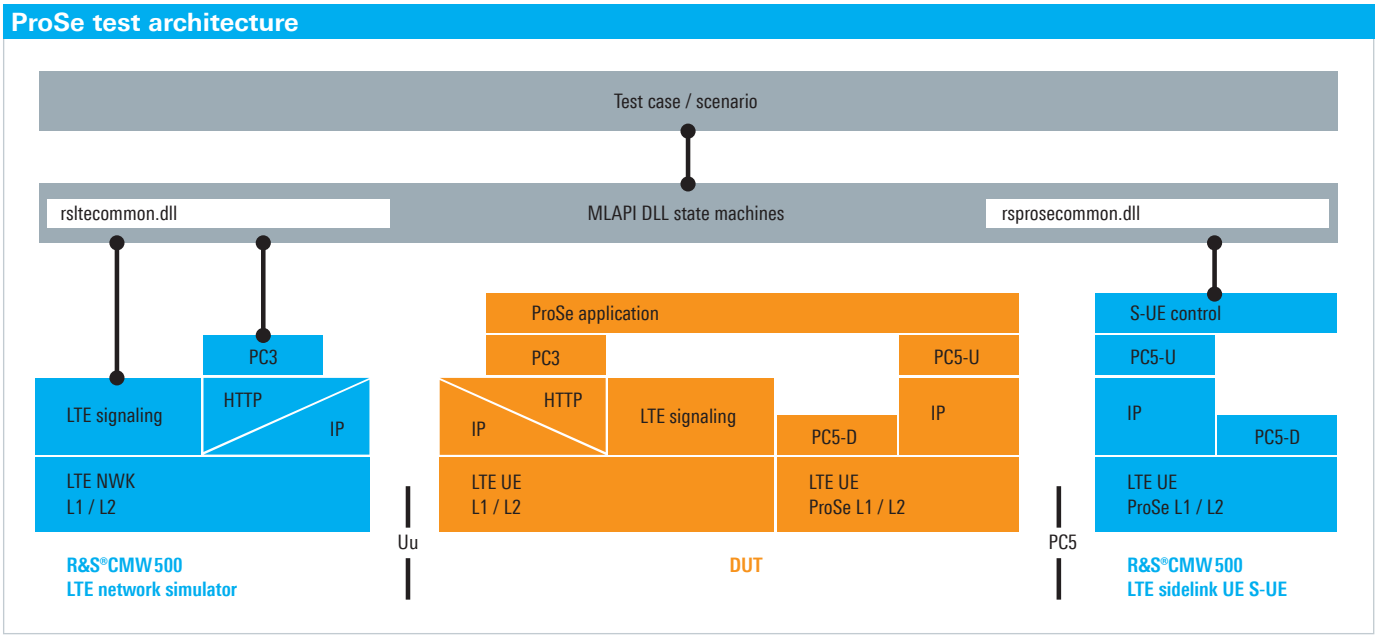

Fig. 3: Test architecture for ProSe tests, consisting of the R&S®CMW500 (blue) and the mobile device (DUT).

Since direct communication is especially important when there is a network outage, a solution had to be found for the problem of compensating for the absence of a common timebase, which is critical for synchronizing UEs. The problem was resolved by ensuring that each UE wishing to transmit that does not find a time reference declares itself as the synchronization master. It then transmits all necessary information that is usually contained in the master information block, such as the system bandwidth and duplex mode (direct synchronization). The sidelink UE simulated by the R&S®CMW500 implements all the functions needed to test the DUT in both roles, both as the synchronization master and as a receiver that needs to synchronize with the master.

Direct synchronization can also be used to extend network coverage. If required, a direct communication enabled UE (though direct synchronization is not restricted to direct communication) at the edge of network coverage can be prompted by the network to take on the role of synchronization master for the UEs in its vicinity. A typical application scenario might be an emergency situation in which the emergency personnel needs to penetrate a building where there is no network reception.

Outlook

The definition of the D2D air interface is far from finalized with 3GPP Release 12. Release 13, for example, will add functionality to turn a UE into a relay node for UEs that are out of coverage. This feature will enable UEs to use direct discovery even when they are not in direct contact with a base station. In addition, a service called mission critical push to talk is being defined. This service will encompass both public safety and commercial applications. Other D2D application areas will include vehicle-to-vehicle communications, although these will only be addressed in future standardization efforts since they require much lower latencies than are currently possible with LTE. For all existing and foreseeable D2D services, the R&S®CMW500 is the tester of choice – for RF, protocol or application testing.

Dr. William Powell

References
[1] White paper "LTE-Advanced (3GPP Rel. 12) Technology Introduction" (search term 1MA252 at www.rohde-schwarz.com).
[2] White paper "Device to Device Communication" by Rohde&Schwarz (search term 1MA264 at www.rohde-schwarz.com).