CHAPTER 3

Digital Cellular Telephony -
GSM (global system fo mobile communication)

3.1 Sub-objectives:

By the end of this course, you will know:

- the general principles common to cellular networks
- understand the architecture of cellular networks and its main components: the access network and the core network: illustration with GSM and LTE
- assimilate the principles of radio interface of cellular networks
- some basic radio procedures
- the expected developments of LTE networks

3.2 *introduction*

An antenna is a radiating device used to transmit or receive signals. In figure 1.a, you can see an antenna mounted at the top of a few dozen heights. The other example (b) is an antenna on a roof. There are others that are hidden (c).

All these antennas are connected with coaxial cables, but the antenna is not the essential part in communication.

a

b

c

figure 1 antennas

What matters most is this small box that will perform the functions necessary to access the network. In other words, the transmission and reception functions are present in this box, called base station **BTS** (**Base Transceiver Station).**

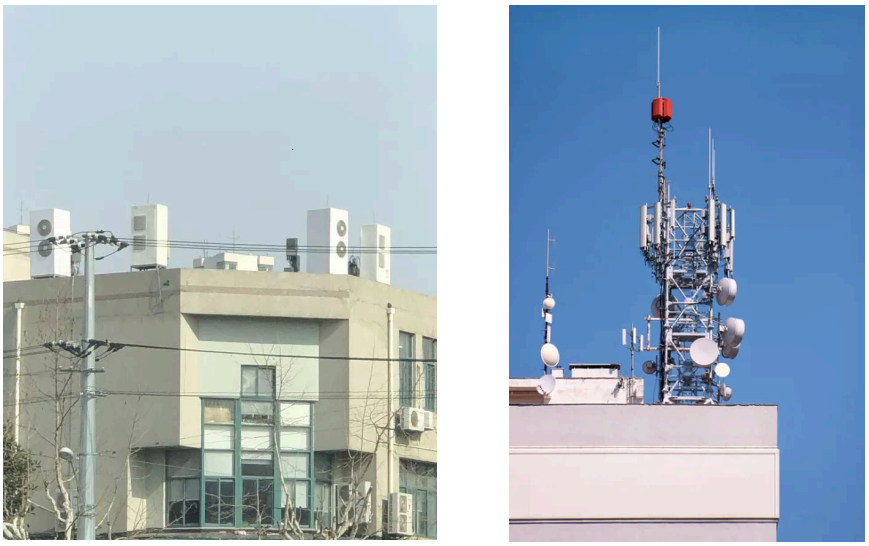


Figure 2 base station BST

3.3 *GSM NETWORK OPERATION AND ARCHITECTURE*

GSM is a second generation cellular standard developed in 1991 by European telecommunications to support voice and data services using digital modulation with TDMA .

GSM was the first generation to introduce a SIM card, the GSM data speed was about 14.4 Kbps , the GSM uses different frequency bands according to regions.

the GSM network architecture contains 4 sub-systems:

- Mobile Station MS
- Base Station Sub-System BSS
- Network Switching Sub-System (NSS)
- Operation support Sub-System

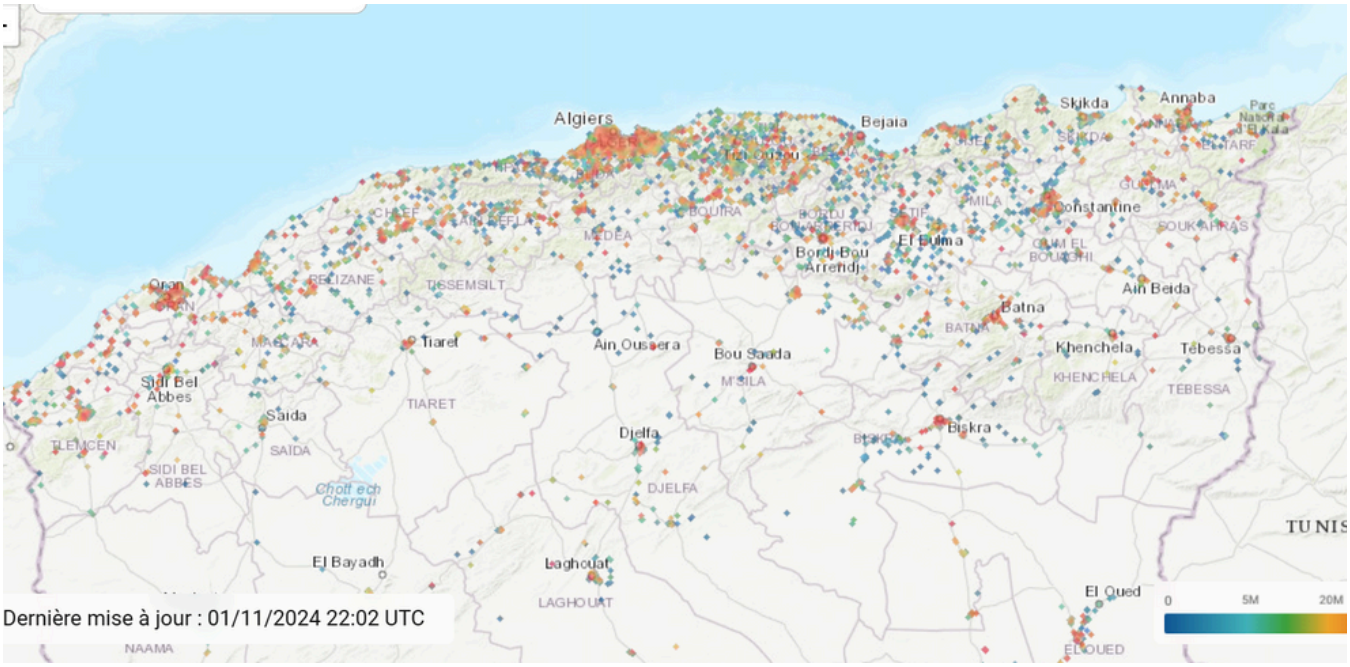
In a GSM network, all transmission-related functions (modulation, demodulation, multiplexing) are performed in the base station (BTS), which is used to locate the recipient of a call.

For a subscriber to call on his smart phone, the transmit power must be between 1 4 and 2 watts, and the terminal (mobile station, telephone) must be located at a reasonable distance from the base station, between a few kilometres and a few tens of kilometres.

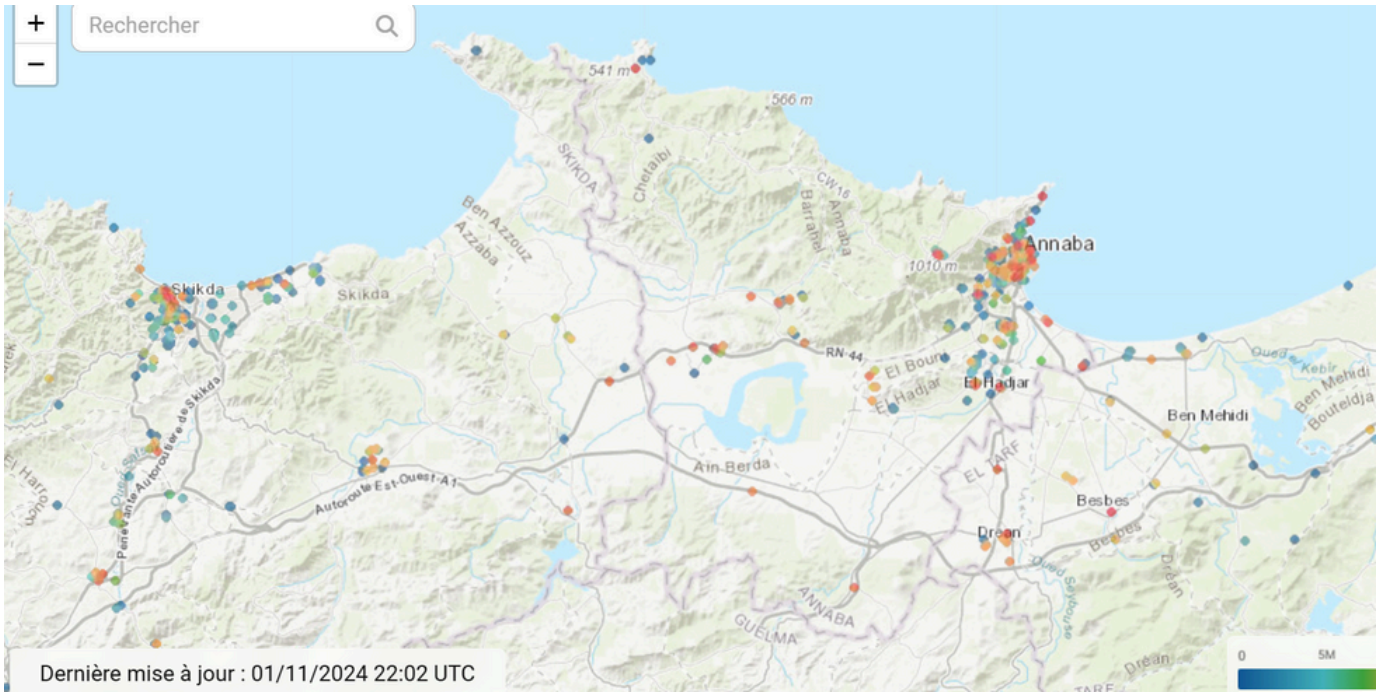
“what does it mean that to cover a territory you need several base stations”, for example:

- **Mobilis operator has 1687 BTS which covers a rate of 70.56%**
- **Operator oredoo has 2719 BTS which covers a rate of 99.47%**

The BTS of the operator Ooredoo, which covers Algeria, is visible on figure 3, and that covering annaba is visible on fig 4:



a



b

Figure 4. The BTS of the operator Ooredoo

Operators install many base stations to cover the entire area of Annaba, so that the territory is divided into cells, The main difficulty of mobile networks will be to provide a continuous service available throughout the territory, This will offer at the terminal (user) the possibility of moving without the cell cut being visible.

so the cell concept is to make a cutout into an invisible cell for the user, a cell will be the geographical area that is covered by the BTS, there will be several difficulties such as:

- the frequency assignment: the operator has a certain number of frequencies available, it will be necessary to reuse the same frequencies on cells that are sufficiently far away
- Location management

The higher the density of users, the higher the density of base stations (as in the case of base stations located in the city centre).

On the other hand, the smaller the density of users, the lower the density of base stations (as in rural areas)

Below, an example of 3 cells of R ray are colored in green. In reality, the complexity varies according to the propagation of waves, Moreover, even if the operators have made efforts, there is a hole that is not covered because it is very far from the 3 stations.

BTTs use voice beacons to inform the terminal (user) through network bars that the network is available, so that the terminal is in the BTS coverage area.

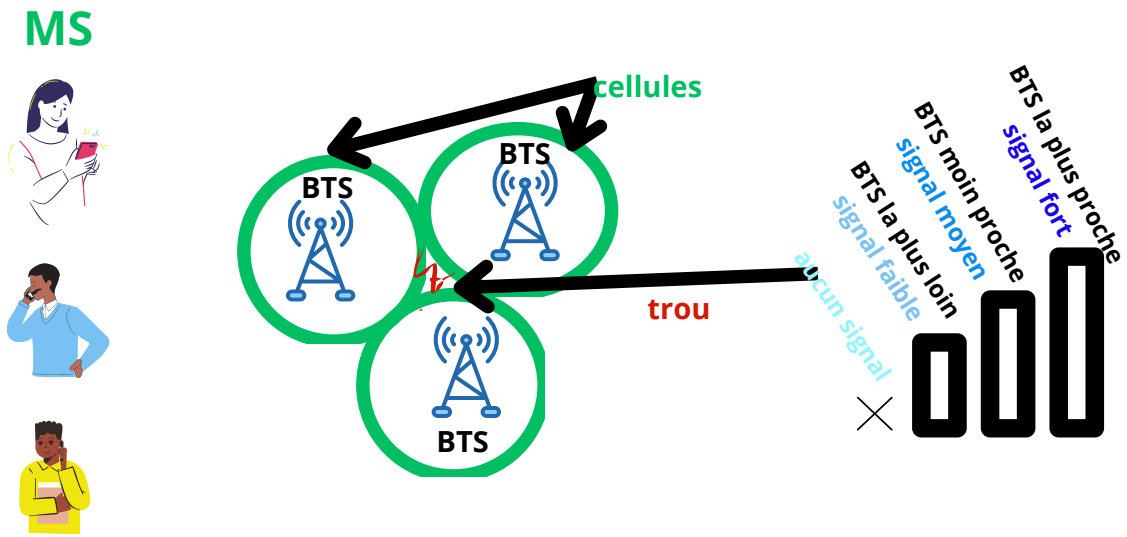


Figure 5. BTS cells in a GSM architecture

so several station bases are connected to a switch, ie the BTS are connected to a single switch called MSC (MOBILE SERVICE SWITCHING center), As the specificity of GSM is to manage mobile subscribers in order to offer a mobile telephony service, it is obvious to manage the location of subscribers, that is to store the location, what we call the HLR (home location register).

In the HLR, for each subscriber:

- the profile, that is to say your subscription rights (example right to make or not to make international calls)
- the location

Several MSCs are connected together, and they exchange information according to the signal of semaphore7 (SS7). Which is developed in the telephone network and for which a particular sequence is presented.

the HLR containing the profile and location of the subscriber and the MSC will also communicate using semaphore signaling 7 (SS7)

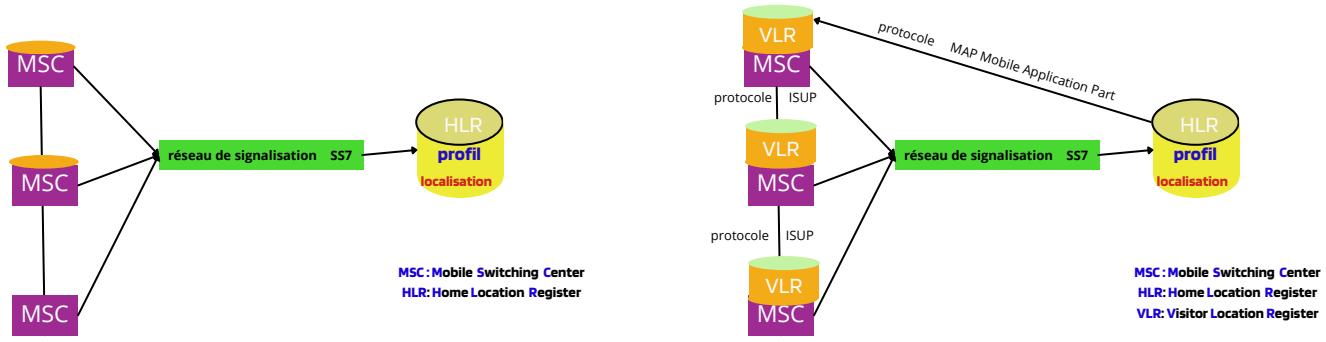


Figure 6. core Network of GSM

In the event that a subscriber related with BST(BTS connected with an MSC switch), wishes to make a phone call, it is necessary for MSC to ask HLR whether the profile has the possibility of benefiting from the service or not.

The HLR reviews the subscriber's profile and responds by specifying whether it is an authorized or unauthorized service.

It should be noted that when several subscribers call, this creates a significant load on HLR.

It is possible to release HLR by transferring the profile to MSC and then consulting it locally between MSC and VLR (Visitor location register)

The **VLR** will record the profile of subscribers present in the area it supervises, it is noted that:

- lthe protocol used for communication between multiple **MSC** is **ISUP** protocol.
- the protocol used to connect **VLR** et **HLR** is the **MAP Mobile Application Part** protocol.

In practice, **MSC** and **VLR** are integrated into the same equipment.

It is concluded that the essential elements of a GSM (**core network**) are: **MSC/VLR** and **HLR**.

In the case of GSM, the link between **BTS** and **MSC/VLR** is point-to-point, where the cost of the link depends on distance (**star network architecture**) figure 7.a.

To reduce link costs, intermediate equipment is installed that ensures the concentration between base stations and **MSC/VLR** (**tree network architecture**) as shown in **Figure 7.b.**

This intermediate equipment is called **BSC** (**Base station controller)**. Its role is to perform the control of the **BTS**. And the **BTS** at this time only provides the functions of transmission and reception of the signal (demodulation, decoding); the link between **BTS** and **BSC** is wired conventional.

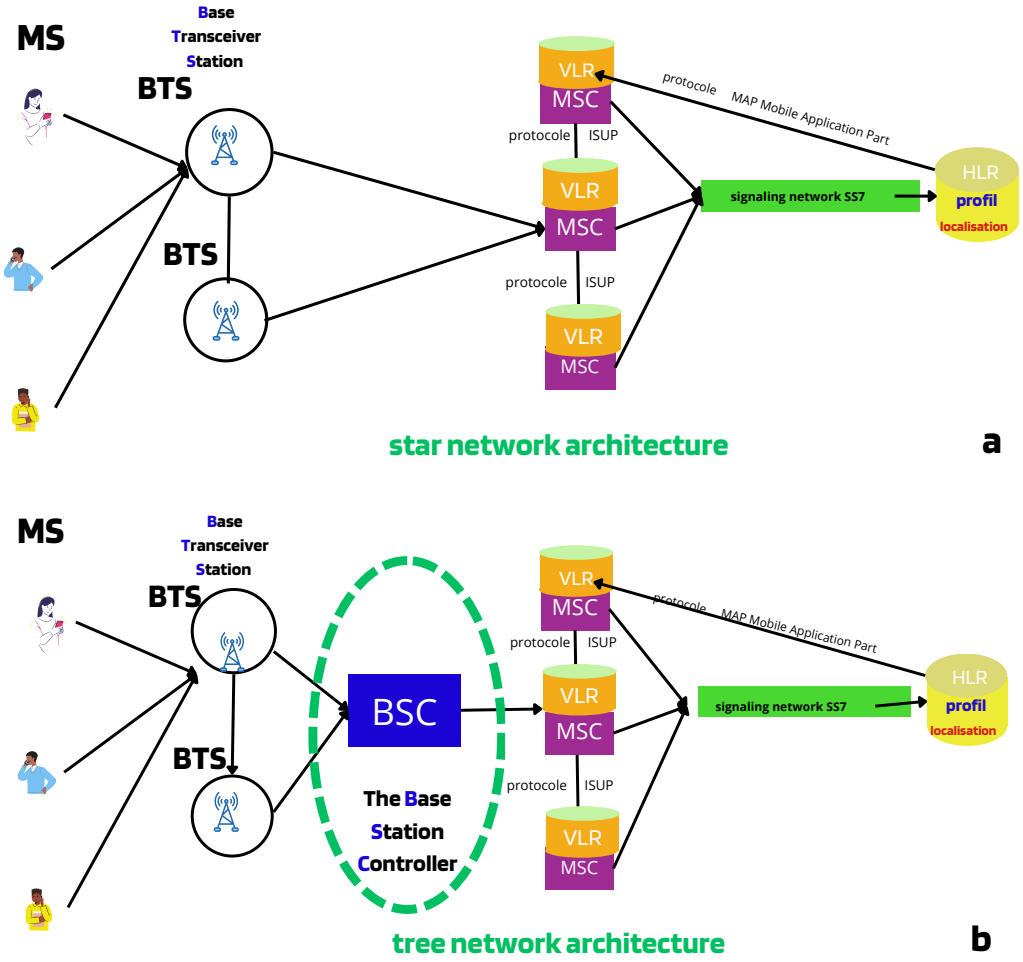


Figure 7. GSM network tree and star architecture (core Network)

Summary

We summarize with some important points:

- MS (mobile station) consists of a mobile device (Mobile equipment ME) and a subscriber identity module (this is the SIM card).
- The operator is meshed by BST base stations
- Several BST are connected to a base station controller known as the BSC (base station controller).
- The BSC Modules are connected to MSC/VLR , the MSC part with basic switching functions and the VLR part with database functions.
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- MSC/VLR are connected to HLR (home location register)
- The BTS and BSC form what is called the access network, or **BSS: base station subsystem**.
- MST/VLR and HLR form the core of the network or **NSS: Network switching subsystem.**
- MSC/VLR and HLR communicate using SS7 (Signal Signal Network Semaphore 7).
- two protocols are used: ISUP protocol between several MSC, and MAP protocol between MSC/VLR and HLR which manages the mobility functions.
- The core network NSS is connected to the PSTN (switched telephone network) and other operators, so that the networks can be interconnected.

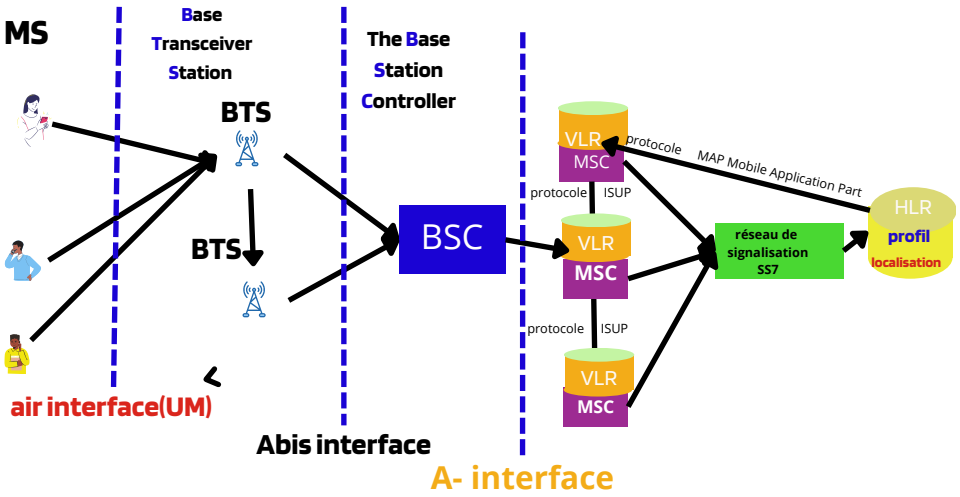
some definitions

HLR (Home Location Registre) : Is the reference database that manages all subscribers and their profiles. A subscriber's profile includes many pieces of information such as their phone number, the services they are entitled to use, additional service information such as call referrals and call restrictions.

MSC/VLR (Mobile Switching Centre/Visitor Location Register) : Corresponds to the switch (MSC) and database (VLR) that provides circuit services to a user terminal present in their area. The MSC allows switching of circuit connections while the VLR contains a copy of the subscriber's profile and some more precise information about the location of the subscriber.

3.4 *The GSM interfaces*

There are 3 important interfaces between the mobile station and the HLR, summarized in Figure 8.a. The table (figure 8.b) shows the different interfaces in detail across the GSM network architecture:



Noms	Localisation	Utilisation
Um	Terminal - BTS	Interface radio
Abis	BTS - BSC	Divers (transfert des communications)
A	BSC - MSC	Divers (transfert des données)
B	MSC - VLR	Divers transfert des données
C	GMSC - HLR	Interrogation HLR pour appel entrant
D(1)	VLR - HLR	Services supplémentaires
D(2)	VLR - HLR	Services supplémentaires
E	MSC - MSC	Exécution du hand over
G	VLR - VLR	Gestion des informations des abonnés

Tableau 1. interfaces de réseau GSM

3.5 *The characteristics of GSM:*

Mobile telephony by GSM occupies two bands of frequencies around 900Mhz.

- 890 to 915 [Mhz] for transmission from the terminal to the network (Up Link),
- 935 to 960 [Mhz] for reverse transmission (Down Link).

LThe bandwidth of each direction is divided into 124 channels of 200 MHz width. These channels are not sufficient in large cities, so it has been necessary to allocate an additional band around 1800 MHz. It is the DCS 1800 system whose characteristics are almost identical to GSM in terms of protocols and service. The ascending communications making then between 1710 and 1785 [Mhz] and descending communications between 1805 and 1880 [Mhz].

GSM uses two multiplexing techniques for the allocation of its frequencies and for the increase in network capacity:

- ☐ Frequency Division Multiple Access (**FDMA**);

- [ ] Time Division Multiple Access (**TDMA**)

another technique is also used CDMA (CODE Division Multiple Access)

1. **FDMA** :FDMA is the most commonly used multiple access method. This technique is the oldest, it allows users to differentiate by a simple frequency differentiation. The implementation of this technology is quite simple. Indeed, to listen to the user N, the receiver only considers the associated FN frequency
2. **TDMA :** TDMA is a method of access based on the allocation of resources over time. Each user transmits or broadcasts in a specific time interval whose periodicity is defined by the frame duration. In this case, to listen to user N, the receiver only has to consider the time interval N associated with that user.
3. **CDMA** : The CDMA is based on code allocation. Each user is differentiated from the rest of the users by an N code that has been allocated to him at the beginning of his communication and which is orthogonal to the rest of the codes related to other users. In this case, to listen for user N, the receiver only needs to multiply the received signal by the N code associated with that user.