GSM VOICE CAPACITY EVOLUTION WITH VAMOS

STRATEGIC WHITE PAPER

TABLE OF CONTENTS

VAMOS INCREASES YOUR GSM VOICE CAPACITY AT MINIMUM INVESTMENT

Ever-increasing GSM mobile traffic, coupled with flat or decreasing ARPU, obliges mobile operators to grow their network infrastructure. This trend pushes them to manage their costs from a global perspective and optimize investments in their Radio Access Network, including usage of their allocated radio spectrum. Voice services over Adaptive Multi-user channels on One Slot (VAMOS) is a 3GPP feature designed to increase the voice capacity of a GSM access network without further hardware investment by optimizing spectrum utilization, while reducing radio base station power consumption.

Alcatel-Lucent complete product portfolio is backward and forward compatible with VAMOS, which can be enabled by a software upgrade for fast and easy deployment at minimum cost. In addition, the full Alcatel-Lucent BSS portfolio is fully IP ready.

TAKE THE FULL BENEFIT OF VAMOS

- Increase your hardware efficiency and optimize your investments: Boost your GSM voice capacity without further hardware investment
- Increase spectral efficiency for broadband extension: Spectrum refarming with W-CDMA/LTE introduction without reduction of GSM voice capacity
- Perform network extension or network renovation (swap) with limited additional hardware investment
- Energy/Power efficiency: Reduce your overall network operational expenses by significantly reducing the power consumption of each BTS where VAMOS feature is activated

STANDARD ASPECTS

Voice services over Adaptive Multi-user channels on One Slot (VAMOS) is the name given by the 3GPP Rel-9 Work Item approved in November 2008, in continuation of the Multi-User Reusing One Slot (MUROS) feasibility study of 3GPP Rel-8.

HOW DOES VAMOS WORK?

VAMOS relies on multiplexing several circuit-switched users on the same radio timeslot. The radio timeslot is shared in both downlink and uplink directions, using the same physical sub-channel, ARFCN and TDMA frame number. However, the multiplexing solution used for VAMOS is not the same method used for Half Rate (HR), where the TDMA frame throughput is shared by two HR users. With VAMOS multiplexing, the 2 users have a simultaneous access to the whole TDMA frame thanks to the introduction of a specific Adaptive QPSK modulation (described here after)".

- The following multiplexing cases are possible:
- Two users in Full Rate,
- Three users in Half Rate.
- Four users in Half Rate.

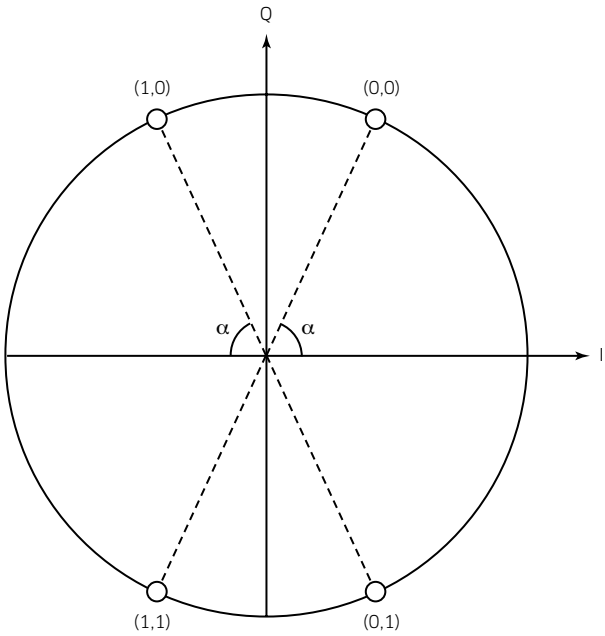
The VAMOS capacity gain will depend on the average radio quality link and the penetration of compatible handsets in the network.

VAMOS MULTIPLEXING PRINCIPLES

The standard has introduced the Adaptive-QPSK modulation to support VAMOS functionality. It is a variant of QPSK modulation allowing to dynamically changing the downlink power ratio between the two paired mobiles. It is needed as they can have different VAMOS capabilities and experience different path losses or radio conditions. This ratio is called SCPIR, standing for Sub-Channel Power Imbalance Ratio.

In downlink, the BTS transmits simultaneously to two paired mobiles on the same timeslot and frequency using Adaptive-QPSK modulation. Each paired mobile receives its component of the Adaptive-QPSK as legacy GMSK, with additional co-channel interference from the other paired mobile. When DL DTX (DTX is a feature suspending voice transmission during silence) is enabled, a speech pause for one of the paired users initiates use of legacy GMSK for the other user, if he is in a speech period.

Figure 1. Adaptive QPSK modulation example

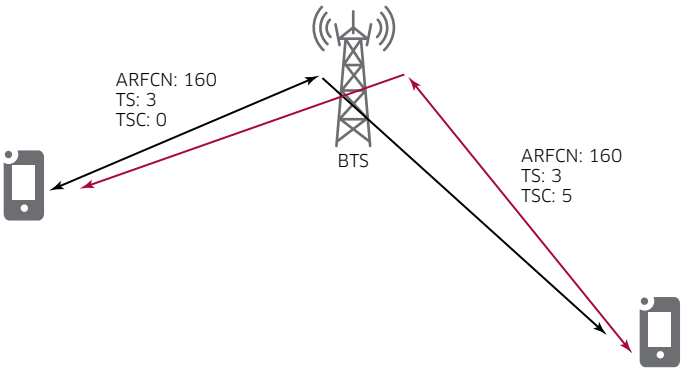


In uplink, Adaptive QPSK is not used. The two mobiles transmit their GMSK modulated signal simultaneously to the BTS on the same timeslot and frequency.

A new set of eight training sequence codes (TSC Set 2) , with improved cross-correlation properties, is introduced and complements the existing set of eight TSCs. In both directions, a TSC belonging to a different TSC set is used by the paired mobile and the BTS. This allows BTS and mobiles to better differentiate the signals coming from and going to the paired mobile, which improves VAMOS performance. SAIC (Single Antenna Interference Cancellation) pairing is handled slightly differently, as explained in the section on Mobiles compatibility here after

The figure 2 summarizes the two main VAMOS principles: frequency/radio timeslots sharing and training sequence usage.

Figure 2. VAMOS, radio channel sharing and TSC usage



VAMOS AND OTHERS FEATURES RECOMMENDATIONS

VAMOS compatible features

- Full Rate (FR)
- Half Rate (FR)
- Enhanced Full-Rate (EFR)
- Adaptive Modulation Rate Full-Rate (AMR FR)
- Adaptive Modulation Rate Half-Rate (AMR HR)
- Wide-Band Adaptive Modulation Rate Full-Rate (WB AMR FR)

The usage of VAMOS on AMR calls is advised to leverage AMR codec resistance against bad radio conditions. O-TCH channels (AMR codec types using 8-PSK) are not supported because VAMOS is applicable to GMSK channels only so WB-AMR HR cannot be supported.

Repeated xACCH features are also advised to consolidate the robustness of the signalling channels associated with VAMOS calls. Moreover, shifted SACCH (3GPP Rel-9) will also be implemented to improve SACCH robustness of VAMOS Level 2 mobiles. Finally, DTX usage is recommended to reduce co-channel interference, which enables higher VAMOS capacity gains.

In order to limit the impacts of VAMOS on the A-bis and A-ter interface dimensioning, an IP Transport solution in the BSS is required. 2 different options are possible:

- Full IP over Ethernet,
- IP over E1 on the A-bis interface (for operators who prefer to keep their existing TDM physical transmissions)

MOBILES COMPATIBILITY

The 3GPP has standardized two types of VAMOS handsets:

- VAMOS Level 1 handset: These SAIC-capable handsets support the new training sequence codes.
- VAMOS Level 2 handset: New interference cancellation algorithms, optimized for VAMOS and improved compared to SAIC, are used when operating in VAMOS mode.

Due to the high level of co-channel interference created by the paired users, VAMOS usage requires advanced mobiles that can operate at very low SIR values with acceptable performance. This is true for VAMOS mobiles, as well as for legacy SAIC mobiles.

When two Legacy SAIC handsets are paired, called "SAIC pairing," the handsets should use different TSCs from TSC Set 1. Legacy non-SAIC handsets should also support VAMOS operations, but only if paired with VAMOS Level 2 handsets. The following table summarizes pairing possibilities, depending on handset capabilities.

Table 1. Mobile pairing possibilities

	LEGACY NON-SAIC	LEGACY SAIC	VAMOS LEVEL 1	VAMOS LEVEL 2
Legacy non-SAIC	No	No	No	Likely yes
Legacy SAIC	No	Yes	Yes	Yes
VAMOS Level 1	No	Yes	Yes	Yes
VAMOS Level 2	Likely yes	Yes	Yes	Yes

- Legacy SAIC mobiles can be used in VAMOS operations to achieve significant capacity gains
- Limited effort to upgrade legacy SAIC mobiles to VAMOS level 1 – Only the new training sequences have to be implemented.
- First VAMOS Level 1 mobiles are expected in 2013.
- VAMOS level 2 mobiles will require more processing and are expected in 2013 or 2014.

VAMOS CAPACITY SIMULATIONS

Alcatel-Lucent has performed simulations on VAMOS which showed significant capacity gains:

- ~70% with VAMOS level 1 mobiles
- ~40% with legacy SAIC mobiles

As VAMOS capable handsets proliferate in the market over time, the feature will strongly help the operators cope with voice quality/capacity challenges. Moreover, and as demonstrated by Alcatel-Lucent simulation results, VAMOS is set to play an important role in preserving GSM voice capacity when refarming spectrum for 3G/LTE introduction.

ACRONYMS

3GPP	3rd Generation Partnership Project
8-PSK	8 Phase Shift Keying
AMR	Adaptive Multi Rate
AMR FR	Adaptive Modulation Rate Full Rate
AMR HR	Adaptive Modulation Rate Half Rate
AQPSK	Adaptive QPSK
ARFCN	Absolute Radio Frequency Channel Number
BTS	Base Transceiver Station
DTX	Discontinuous Transmission
EFR	Enhanced Full-Rate
FACCH	Fast Associated Control CHannel
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
HR	Half-Rate
O-TCH	Octal Traffic Channel
SACCH	Slow Associated Control CHannel
SAIC	Single Antenna Interference Cancellation
SCPIR	Sub-Channel Power Imbalance Ratio
SIR	Signal to Interference Ratio
TCH	Traffic CHannel
TDMA	Time Division Multiple Access
TRX	Transceiver
TS	Training Sequence
TSC	Training Sequence Code
VAMOS	Voice services over Adaptive Multi-user channels on One Slot
WB-AMR FR	Wide-Band AMR FR
xACCH	SACCH or FACCH

Alcatel·Lucent