3GPP TSG RAN WG2 Meeting #125 R2-23xxxxx

**Athens, Greece,** **26th Feb – 1st Mar****, 2024**

**Agenda item:** 7.4.1

**Source:** Intel Corporation (Rapporteur)

**Title:** Report of [Post124][561][feMob] UE capability (Intel)

**Document for:** Report

# Introduction

UE capability signalling required for feMob was discussed in R2-123 based [1]. Additional contributions related to capability were also provided to the meeting [2][3]. The meeting discussion and agreements captured in the chair’s notes were:

R2-2313590 Discussion and TP on L2/3 UE capabilities for NR further mobility enhancements Intel Corporation discussion Rel-18 NR\_Mob\_enh2-Core

- Intel: p7 already agreed

- Nokia: RACH less should be mandatory for LTM. Ericsson agrees. Apple disagrees.

- MTK has sympathy for Nokia, but think RAN1 Feature list indicate this as optional.

- FW: think we should have conclusion on UE based TA mgmt.

- QC: UE cap is also about testing etc, can keep this optional.

- Chair: no other comments.

* Assume support for RACH-less Is optional (follow R1 feature list)
* P7 already, other parts seem agreeable (can discuss in email discussion)

The email discussion and scope are captured as follows:

* [Post124][561][feMob] UE capability (Intel)

Scope: Discussion on UE caps (based on input to this meeting and can include new input).

Intended outcome: report and agreeable CR

Deadline: Long

Two phases are proposed to progress the discussion:

**Phase 1:** Collect company comments on the proposals in [1] that was almost agreeable

Collect company comments on additional capabilities proposed in the other contributions provided to R2-124 [2],[3]

Companies to provide propose any additional capabilities; other companies can comment on these proposed new capabilities already in phase 1 if possible (e.g., new capabilities are provided early).

**Deadline to provide phase 1 comments: 26th January 2024**

Phase 2: Comments on additional new capabilities provided by companies in phase 1

Comments on provided draft CR

Deadline: Deadline 9th February 2024

Company contact person:

|  |  |  |
| --- | --- | --- |
| ***Company*** | ***Name*** | ***Email address*** |
| MediaTek | Li-Chuan TSENG | li-chuan.tseng@mediatek.com |
| Xiaomi | Yumin Wu | wuyumin@xiaomi.com |
| Apple | Naveen Palle | naveen\_palle@apple.com |
| Ericsson | Antonino Orsino | antonino.orsino@ericsson.com |

# Discussion

The current list of RAN1 capabilities is shown below for information:

|  |  |
| --- | --- |
| Index | Feature group |
| 45-1 | Intra-frequency L1 measurement and reports for L1-L2 Triggered Mobility (LTM) procedure |
| 45-1a | Inter-frequency L1 measurement and reports for L1-L2 Triggered Mobility (LTM) procedure |
| 45-2 | Inclusion of current SpCell in the L1 measurement report |
| 45-3 | Beam indication with joint DL/UL LTM TCI states |
| 45-3a | MAC-CE activated joint LTM TCI states |
| 45-4 | Beam indication with separate DL/UL LTM TCI states |
| 45-4a | MAC-CE activated DL/UL LTM TCI states |
| 45-5 | RACH-based early TA acquisition |
| 45-5a | RACH-based early TA acquisition with simultaneous transmission |
| 45-6 | UE-based TA measurement |
| 45-7 | TA indication in cell switch command |

The following RAN2 capabilities have already been agreed and is not part of the discussion

**Observation #1: Reference configuration for LTM is optional**

**Observation #2: Number of supported candidate cells maxNrofCondCells for CHO+CPAC is fixed at 8**

As the above two are already agreed, they not discussed in this document.

## LTM:

The discussion below on possible additional capabilities.

The feature list below is from [1] and seems largely agreeable during R1-124.

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| --- | --- | --- | --- | --- | --- |
| ***Feature #***  ***(LTM to be replaced by feature #)*** | ***Feature/ scenario*** | ***Capability signalling*** | ***Other aspects*** | ***Related RAN1 features*** | ***Remarks*** |
| LTM-1 | MCG LTM | Optional feature  Supported components:  Single cell switch LTM and subsequent LTM  MAC CE based cell switch command;  Preconfiguration of LTM candidate cell | Per UE, no FRx/xDD differentiation | Supports RAN1 intra-frequency L1 measurement and report (45-1) |  |
| LTM-2 | SCG LTM | Optional feature  Supported components:  MAC CE based cell switch command;  Preconfiguration of LTM candidate cell | Per UE, no FRx/xDD differentiation | Supports RAN1 intra-frequency L1 measurement and report (45-1) | Separate capabilities for SCG LTM and MCG LTM |
| LTM-3 | RACHless LTM with DG for MCG | Optional feature  Dependencies:  UE shall indicate support of MCG LTM | Per UE, no FRx/xDD differentiation | Supports RAN1 capability of joint or separate TCI state in MAC CE (45-3 or 45-4)  Supports RAN1 TA indication in cell switch command (45-7) | None of the RAN1 features cover this directly.  Hence need a capability just for this.  Separate capability for MCG RACHless CG and DG |
| LTM-4 | RACHless LTM with CG for MCG | Optional feature  Dependencies:  UE shall indicate support of MCG LTM | Per UE, no FRx/xDD differentiation | Supports RAN1 capability of joint or separate TCI state in MAC CE (45-3 or 45-4)  Supports RAN1 TA indication in cell switch command (45-7) | Separate capability for MCG RACHless CG and DG |
| LTM-5 | RACHless LTM with DG for SCG | Optional feature  Dependencies:  UE shall indicate support of SCG LTM | Per UE, no FRx/xDD differentiation | Supports RAN1 capability of joint or separate TCI state in MAC CE (45-3 or 45-4)  Supports RAN1 TA indication in cell switch command (45-7) | Separate capability for SCG RACHlesss CG and DG |
| LTM-6 | RACHless LTM with CG for SCG | Optional feature  Dependencies:  UE shall indicate support of SCG LTM | Per UE, no FRx/xDD differentiation | Supports RAN1 capability of joint or separate TCI state in MAC CE (45-3 or 45-4)  Supports RAN1 TA indication in cell switch command (45-7) | Separate capability for SCG RACHlesss CG and DG |

Q1: Companies are invited to provide comments on the above features or if finer granularity is needed.

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| --- | --- | --- |
| **Company** | **Feature #** | **Comments** |
| MediaTek | LTM-1, LTM-2 | RACH-less LTM is optional as per R1 feature list, and thus RACH-based LTM could be mandatory for the UE, i.e., the support of RACH-based LTM is included in LTM-1 and LTM-2.  Alternatively, since the RACH-less LTM provides shorter cell switch interruption than RACH based LTM, we think it is possible that the network vendors will prefer RACH-less LTM over RACH based LTM in the practical network implementation and deployment. Because of that, there might not exist any IOT opportunities for RACH based LTM. For this reason, we may add an additional UE capability to indicate support of RACH based LTM (separately for MCG and SCG). A UE which supports LTM for a cell group should indicate support at least one type of LTM (i.e., at least one of: RACH based LTM, RACH-less LTM with CG, RACH-less LTM with DG) for the cell group.  Moreover, it is OK to use single IE to report MCG LTM support per UE. But we suggest mentioning that the NW refer to *handoverFDD-TDD*, *handoverFR1-FR2* capability to configure the candidate cells.  Otherwise, just like CHO, shall define the IEs for FDD-TDD LTM switch and FR1-FR2 LTM switch. |
| Xiaomi | LTM-1/2/3/4/5/6 | For LTM-1/2, agree with MediaTek that RACH should be mandatory for LTM, and RACH-less should be optional for LTM.  For LTM-3/4/5/6, the UE can support either the TA indication in the cell switch MAC CE or the UE-based TA, in order to support RACH-less LTM. |
| Apple | LTM1/2 | RAN1 has not discussed TDD/FDD (or per-FR) but only intra and inter-freq, for reporting meas, but for actual LTM switch, we think it would help to have IOT testing for FDD-TDD LTM switches, and which would mean we follow the same logic of mandatory capability as we did for legacy HO - *handoverFDD-TDD*, *handoverFR1-FR2*  We are ok with RACH based LTM as mandatory tagged with LTM-1/2 |
| Ericsson | LTM-1, LTM-3, LTM-4, LTM-5, LTM-6 | LTM-1   * From the capability signalling description, we think that we should delete “subsequent LTM” and “LTM pre-configuration”. This is because “subsequent LTM” is not a feature per-se and thus there is nothing explicit standardized to support it. For the “LTM pre-configuration”, this is a mandatory feature for the UE if LTM is supported, otherwise we don’t see how LTM can be configured. We also agree with the points raised by MTK.   LTM-3, LTM-4, LTM-5, LTM6   * We are wondering whether 4 capabilities are really needed. We think it would be sufficient with two to indicate DG and/or CG, and then they apply to both MCG/SCG, depending on what is indicated in the two first capabilities on MCG/SCG. |

Additionally, there were proposals in [2],[3], some of which are not directly related to capability and hence not discussed here. One RAN2 capability mentioned in [3] and to be discussed here:

Q2: Companies are invited to provided comments on the following proposal from [3]:

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| ***Feature #***  ***(LTM to be replaced by feature #)*** | ***Feature/ scenario*** | ***Capability signalling*** | ***Other aspects*** | ***Related RAN1 features*** |
| LTM-7 | A capability to inform the network that the UE supports LTM recovery should be defined | Optional feature  Dependencies:  UE shall indicate support of MCG/SCG LTM | Per UE, no FRx/xDD differentiation | None |

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| **Company** | **Support a capability for LTM recovery as above: Yes/No** | **Comments** |
| MediaTek | Yes | Since LTM recovery is related to RRC connection re-establishment procedure, it is not related to SCG LTM. Therefore, the support of LTM recovery has a dependency only to the support of MCG LTM, but not to the support of SCG LTM. |
| Xiaomi | Yes | Agree with MediaTek |
| Apple | Yes, but | We agree a new capability is needed. But the functionality of LTM SCG is slightly different than MCG LTM. But we assume that the support of LTM-7 for SCG would require the support of LTM-2 (SCG LTM support). So this linkage is important to have in field description of this capability. |
| Ericsson | Yes | Agree with MTK that this should only be for the MCG. |

Many of the proposals in [2][3] are related to updates to the R1 feature list and seems some of them are already discussed in RAN1 and some updates to the feature list were already agreed by RAN1. Hence these are also not listed but companies are invited to add if something in RAN1 feature list needs to be discussed further in RAN2.

Q3: Companies are invited to provide comments on any RAN1 feature list that require discussion in RAN2:

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| **Company** | **RAN1 feature # (45-x)** | **Comments** |
| MediaTek |  | (RAN1 has revised their feature list in Nov. meeting, and we should follow that.) |
| Xiaomi |  | Agree to check the latest status of RAN1. |

Some companies mentioned that it would be useful to have the following capabilities as the SCG release/update handling during LTM may not be so simple.

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| ***Feature #***  ***(LTM to be replaced by feature #)*** | ***Feature/ scenario*** | ***Capability signalling*** | ***Other aspects*** | ***Related RAN1 features*** |
| LTM-8 | MCG LTM with SCG release at LTM execution | Optional feature  Dependencies:  UE shall indicate support of MCG LTM | Per UE, no FRx/xDD differentiation | None |
| LTM-9 | MCG LTM with SCG remaining at LTM execution | Optional feature  Dependencies:  UE shall indicate support of MCG LTM | Per UE, no FRx/xDD differentiation |  |

Q4: Companies are invited to provide comments on the need for the above features.

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| **Company** | **Support capability for LTM-8/9: Yes/No** | **Comments** |
| MediaTek | Yes | A UE which supports MCG LTM and NR-DC should support LTM-8, LTM-9, or both.  Alternatively, since whether to keep SCG is a generic behaviour for SCG when MCG LTM happened (keeping the SCG if BC is supported, releasing SCG otherwise), LTM-8 could be merged to LTM-1 as baseline behaviour and only create one capability as LTM-9. |
| Xiaomi | Yes | We think that LTM-8 and LTM-9 would require different UE implementations, which is different from the legacy DC configuration/reconfiguration/release of SCG at MCG change. It is difficult to justify which capability is easier than another. We would prefer to keep the two bits independent as suggested by the email discussion rapporteur, and not to merge LTM-8 to LTM-1. |
| Apple | LTM-8 should be the default UE functionality |  |
| Ericsson | No | It seems that these capabilities are unnecessary since keeping SCG requires no UE actions and thus there is no really a justification to have a capability. For releasing SCG there is some UE action, but this should be implemented anyway if the UE support LTM (in general). |

## Subsequent CPAC in NR-DC

There are no related RAN1 features for this objective.

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| ***Feature #***  ***(SCPAC to be replaced by feature #)*** | ***Feature/ scenario*** | ***Capability signalling*** | ***Other aspects*** | ***Remarks*** |
| SCPAC-1 | SCPAC MN configured with MN event | Optional feature  (Also supports list of SK-counter)  Dependencies:  UE supports  *mn-InitiatedCondPSCellChangeNRDC-r17*  or  *condPSCellAdditionNRDC-r17* | Per UE, no FRx/xDD differentiation | Capability for the main feature for MN initiated SCPAC |
| SCPAC-2 | SCPAC MN configured with SN event | Optional feature  (also supports list of SK-counter)  Dependencies:  UE supports  *sn-InitiatedCondPSCellChangeNRDC-r17* | Per UE, no FRx/xDD differentiation | Capability for the main feature for SN initiated inter-SN and MN involved intra-SN SCPAC |
| SCPAC-3 | SCPAC SN configured | Optional feature  Dependencies:  UE supports  *condPSCellChange-r16* | Per UE, no FRx/xDD differentiation | Capability for the main feature for SN initiated intra-SN SCPAC |
| SCPAC-4 | Reference configuration for MN configured SCPAC | Optional feature  Can include both MCG and SCG configurations  Dependencies:  UE supports SCPAC-1 or SCPAC-2 | Per UE, no FRx/xDD differentiation | As this reference configuration handling is different to LTM and also because this reference configuration may include MCG and SCG configurations, it seems reasonable to have a separate capability for the reference configuration for SCPAC |
| SCPAC-5 | Reference configuration for SN configured SCPAC | Optional feature  Includes SCG configuration  Dependencies:  UE supports SCPAC-3 | Per UE, no FRx/xDD differentiation | As this reference configuration handling is different to LTM and the use of reference configuration for SCG is different, it seems reasonable to have a separate capability for the reference configuration for SN configured SCPAC |

Q5: Companies are invited to provide comments on the above features. If further split of a feature is suggested, please list the additional split capabilities in the comment column.

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| **Company** | **Feature #** | **Comments** |
| MediaTek | all | OK |
| Xiaomi | SCPAC-1 | For SCPAC-1(the main feature for MN initiated SCPAC) :  In the TS37.340 i00:  For both MN and SN initiated inter-SN subsequent CPAC, the candidate SN generates the execution conditions for the following execution of subsequent CPAC when the candidate SN prepares the candidate SCG configuration(s) for candidate PSCell(s).  In the MN initiated inter-SN subsequent CPAC, the execution of subsequent CPAC uses the candidate SN configured measurement as triggering condition. Hence, for the dependencies, UE supports **sn-InitiatedCondPSCellChangeNRDC-r17 and mn-InitiatedCondPSCellChangeNRDC-r17**, **or** UE supports **sn-InitiatedCondPSCellChangeNRDC-r17 and condPSCellAdditionNRDC-r17**, in order to support SCPAC-1.  OK for SCPAC-2/3/4/5. |
| **Apple** | **Ok for all** |  |
| Ericsson | SCPAC-2 | In MN initiated SCPAC, the execution conditions for the subsequent configuration is SN configured, so the UE needs to support both MN and SN configured events also for MN initiated SCPAC. It seems like capability 1 and 2 should be merged.  Agreement:  "For MN-initiated subsequent CPAC, the execution condition configuration is provided as following:  MN generates the execution conditions (A4 event) for initial CPAC execution, and the measID refers to the measurement configuration associated with MCG;  candidate SN generates the execution conditions (A3/A5 event) for subsequent CPC execution, and the measID refers to the measurement configuration associated with SCG." |

Interaction of SCPAC with legacy CPAC brings up some additional scenarios, some of which are listed below.

* *condPSCellChangeTwoTriggerEvents-r16*
* *condPSCellChangeFDD-TDD-r16*
* *condPSCellChangeFR1-FR2-r16*
* *inter-SN-condPSCellChangeFDD-TDD-NRDC-r17*
* *inter-SN-condPSCellChangeFR1-FR2-NRDC-r17*

If the UE indicates support for these Rel-17 CPAC features and an Rel-18 SCPAC, it implies that UE supports the combination of SCPAC with these Rel-17 CPAC features.

Q6: Companies are invited to comment on whether it is acceptable that a UE indicating support for these Rel-17 CPAC features and a Rel-18 SCPAC, supports the combination of SCPAC with the corresponding Rel-17 CPAC features.

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes |  |
| Xiaomi | Yes |  |
| Apple | Ok |  |
| Ericsson | Yes |  |

## CHO including target MCG and candidate SCGs for CPC CPA in NR-DC

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| --- | --- | --- | --- | --- |
| ***Feature #*** | ***Feature/ scenario*** | ***Capability signalling*** | ***Other aspects*** | ***Remarks*** |
| CHO+CPAC-1 | CHO with candidate SCG for CPC/CPA | Optional feature  Dependencies:  UE shall support CHO  and any one of the CPC or CPA features | Per UE, no FRx/xDD differentiation | Capability for the main feature |

Q7: Companies are invited to provide comments on the above feature. If further split of the feature is suggested, please list additional split capabilities in the comment column.

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| **Company** | **Comments** |
| MediaTek | We think there should not be a dependency to "any one of the CPC or CPA features", as proposal 5 in [1]. The UE could support this feature without supporting any legacy CPC or CPA features.  Please note that "CHO with candidate SCGs" is NOT equal to supporting "CHO+CPAC" feature. It is basically the same flow as CHO with the change that candidate PSCell is also be evaluated in the execution condition. |
| Xiaomi | First, we think we can discuss whether the Rel-18 CHO with Candidate SCG(s) is the combination of CHO +CPAC, or the enhancement of CHO, or an independent feature.  If it is “CHO +CPAC”, for Q7, UE supports CHO and MN initiated CPC or CPA features, in order to support Rel-18 CHO with candidate SCG(s). Because the CPA/CPC condition is always based on source MN measConfig.  If the Rel-18 CHO with candidate SCG(s) is considered as “the enhancement of CHO”, there should not be a dependency to CPC or CPA features.  If it is an independent feature, there should not be a dependency to CHO feature and CPC or CPA features. |
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Interaction of legacy CHO and CPAC causes many additional combinations and it could be useful to double check if they need separate capability bits, perhaps from IOT perspective.

The following are the legacy CHO and CPAC features that have dedicated capabilities

*CHO: condHandoverTwoTriggerEvents-r16, eventA4BasedCondHandover-r17, locationBasedCondHandover-r17, timeBasedCondHandover-r17, condHandoverFDD-TDD-r16, condHandoverFR1-FR2-r16*

*CPAC: condPSCellChangeTwoTriggerEvents-r16, mn-InitiatedCondPSCellChangeNRDC-r17, sn-InitiatedCondPSCellChangeNRDC-r17, condPSCellChangeFDD-TDD-r16, condPSCellChangeFR1-FR2-r16, inter-SN-condPSCellChangeFDD-TDD-NRDC-r17, inter-SN-condPSCellChangeFR1-FR2-NRDC-r17*

When we have a combination of CHO+CPAC, it seems reasonable to assume that if a UE indicates supports for these legacy features and a combination of CHO+CPAC is supported, it implies UE supports the combination of these features.

Q8: Companies are invited to comment on whether it is acceptable that a UE indicating support for these Rel-16/17 CHO and CPAC features and the Rel-18 CHO+CAPC feature, supports the combination of CHO+CPAC with the corresponding Rel-16/17 CHO and CPAC features.

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | No | We think that the Rel-18 CHO with candidate SCGs feature should not be understood to be a direct combination of Rel-16/Rel-17 CHO + CPAC features. It is a feature of its own, with properties which are specific to this feature alone (for example, in CHO with candidate SCGs, the CPA/CPC condition is always based on source MN *measConfig*).  We are okay with the question if “Rel-18 CHO+CAPC” is replaced with “Rel-18 CHO with candidate SCGs”. At least no additional capability is needed for now for the “combination”. |
| Xiaomi | See comments | See our comments for Q7:  If it is “CHO +CPAC”. Q8 is yes. But eventA4BasedCondHandover-r17, locationBasedCondHandover-r17, timeBasedCondHandover-r17 are used for NTN. And Rel-18 CHO with candidate SCG is not supported in NTN. So these features shouldn’t be considered.  sn-InitiatedCondPSCellChangeNRDC-r17, condPSCellChangeFDD-TDD-r16, condPSCellChangeFR1-FR2-r16 are used for SN initiated inter/intra-SN CPC and these features shouldn’t be considered because the CPA/CPC condition is always based on source MN measConfig.  If the Rel-18 CHO with candidate SCG(s) is considered as “the enhancement of CHO”, the legacy CHO features can be used. For the candidate PSCell and associated conditions, new separate capabilities are needed.  If it is an independent feature, separate capabilities are needed for the combination of Rel-18 CHO with candidate SCG(s) and the above features. |
| Ericsson | Yes |  |

## Inclusion of the features in TS 38.306

As LTM features are related to measurement and mobility, it was proposed [1] to include the LTM related features in the *MeasAndMobParameters.*

Q9: Companies are invited to comment whether it is acceptable to include the LTM in the *MeasAndMobParameters.*

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes |  |
| Xiaomi | Yes |  |
| Ericsson | Yes |  |

As the SCPAC and CHO with CPAC are related to MRDC, it was proposed [1] to include the SCPAC and CHO+CPAC in the *MeasAndMobParametersMRDC.*

Q10: Companies are invited to comment whether it is acceptable to include the LTM related features in the *MeasAndMobParameters.*

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| **Company** | **Yes/No** | **Comments** |
| MediaTek | Yes | We assume that this question is for SCPAC and CHO with candidate SCG, not for LTM. (LTM is mentioned in the question.) |
| Xiaomi | Yes | Agree to include the SCPAC and CHO with candidate SCG(s) related features in the MeasAndMobParametersMRDC. |
| Ericsson | Yes | Seems this to be for SCPAC |

## Any other comments

Q11: Companies are invited to provide any comments not covered to the above questions*.*

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| **Company** | **Comments** |
| Ericsson | We are wondering whether it is necessary to define a capability whether UE supports LTM for UE in NR-DC. It is related to the first two capabilities LTM-1 and LTM-2, but not exactly the same, i.e. UE supports LTM on MCG for UE in NR-DC |
|  |  |

# Summary and proposals

TBD

# References

[1] R2-2313590 Discussion and TP on L2/3 UE capabilities for NR further mobility enhancements Intel Corporation

[2] R2-2312504 UE Capability for LTM MediaTek Inc.

[3] R2-2313363 On UE Capabilities for LTM Nokia, Nokia Shanghai Bell