Location Based Services

• LBS market from USD 16 billion in 2019 to USD 40 billion by 2024
• 60% of the global LBS revenues taken by very few leading players

• Global navigation satellite systems’ technology integrated in the end user device and custom over-the-top (OTT) technologies.
• Critical applications demand for technologies deeply integrated in the mobile network ecosystem
Cellular Localization

Positioning technology

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RAT-dependent

RAT-independent

## 5G Location Service Levels

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<td>3m</td>
<td>99%</td>
<td>1s</td>
</tr>
<tr>
<td>2  A</td>
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<tr>
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<td>2m</td>
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Service requirements for the 5G system, 3rd Generation Partnership Project 3GPP™ TS 22.261
# 5G Location Service Levels

Service requirements for the 5G system, 3rd Generation Partnership Project 3GPP™ TS 22.261

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<td>Outdoor</td>
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<td>1s</td>
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<td>99%</td>
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Examples of Safety-critical Applications: eV2X

**Advanced Driving** allowing vehicles to coordinate their trajectories or maneuvers (maneuver coordination)
Positioning [m] 1.5 (3σ)

**Extended Sensors** enables the exchange of raw or processed data gathered through local sensors or live video data
Positioning [m] 0.1m~0.5 m (3σ)

**Remote Driving** enables a remote driver or a V2X application to operate a remote vehicle
Positioning [m] 0.1 (3σ)*

5G; Service requirements for enhanced V2X scenarios” (3GPP TS 22.186 version 16.2.0 Release 16, Nov 2020)
*5GAA Whitepaper, C-V2X Use Cases Volume II: Examples and Service Level Requirements
3GPP Positioning and Synchronization

• 5G Localization methods rely on accurate timing (e.g., OTDOA, Observed Time Difference of Arrival)

• The synchronization requirements depends on the location accuracy requirements:
  - As an example, to achieve a location accuracy of 40-60m, a relative time error less than 200 ns is required.

• Other source of timing errors are the presence of NLOS conditions and the multipath propagation

3GPP TR 37.857 “Study on indoor positioning enhancements for UTRA and LTE”
Typical target requirement is about 1 us with respect to an absolute reference. In order to meet 3 us Cell Phase Synchronization, synchronization is required for:

- controlling interferences in TDD
- combining radio signals in Carrier Aggregation, Dual Connectivity
The Project LOCUS (H2020)

LOCAlization and analytics on-demand embedded in the 5G ecosystem, for Ubiquitous vertical applicationS

• Enabling accurate and ubiquitous location information as a network-native service
• Derivation of complex features and behavioural patterns from raw location and physical events for application developers (location-based analytics)
• Localization of terminals for improving network performance and to better manage and operate networks

The Project LOCUS (H2020)

• Classic localization techniques rely on single value estimates (SVE), e.g. distance/angle, which are jointly used together with prior information by a localization algorithm.

Example: accurate estimation, no synch errors
OTDOA-based localization

- Timing error

Example: one time measurement from a base station has 100 ns error

Localization error: 14.21 m
Example with OTDOA-based localization

Example: 100 ns error

SVE-based

Localization error: 14.21 m

SI-based

Localization error: 0.35 m

Methodology for Soft-Information Machine Learning

Off-line Stage

\[
\{y^{(k)}, \theta^{(p^{(k)})}\} \quad \{\psi(y^{(k)}), \theta^{(p^{(k)})}\}
\]

On-line Stage

\[
y^{(\text{new})} \quad \psi(y^{(\text{new})}) \quad \mathcal{L}_{y^{(\text{new})}}(\theta^{(p)})
\]

• **H2020 LOCUS project**: Localization and analytics on-demand embedded in 5G ecosystem, for ubiquitous vertical applications.
Summary

• Positioning is a key enabler for a wide range of emerging applications in 5G scenarios

• The European Project LOCUS is aiming at improving localization accuracy, close to theoretical bounds and extend localization with physical analytics

• Synchronization and timing are vital for addressing accurate localization in critical scenarios, e.g. safety-critical ones

• Extremely accurate synchronization could result in unreasonable cost for a network operator:
  • Soft-Information is a new paradigm for learning and exploiting location information and mitigate several error sources including synchronization and timing errors due to impaired wireless propagation; preliminary results show SI to outperform SOA localization methods
Thank you

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