Using cellular infrastructures data to foster the transition towards smart cities: a systematic mapping

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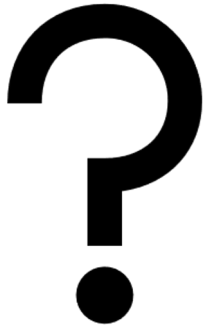
Introduction

- Smartphones connected to the cellular network generate records about connection information (Call Details Record- **CDR**), creating considerable amounts of telecommunications data, which **creates an opportunity to support city management,** namely to foster the smart cities concept.

- CDR - Call data records contain an enormous amount of information on how, when, and with whom or what we communicate.

Objectives

Identify the challenges and opportunities for using CDR to foster smart cities



Research Questions:

RQ1. Which **ISO37122 smart services** groups are using CDR to enable services?

RQ2. How **smart services** use CDR and their main objectives?

RQ3. What are the challenges of using CDR for managing smart cities through control centers?

Methods

These are the steps:

(1) Definition of research protocol;

(2) The application of the search in scientific research bases;

(3) The selection, prioritization, and refinement of search results;

(4) Critical analysis.

Strings and criteria

((("call detail record" OR "call detail records" OR "call details records" OR "calls details records") AND ("smart city" OR "smart cities" OR "smart finance" OR "smart grid" OR "smart health" OR "smart housing" OR "smart logistics" OR "smart mobility" OR "smart payment" OR "smart tourism" OR "smart environment")))

Web of Science	IEEE Xplore	ACM Digital Library	Scopus

Inclusion Criteria

studies that represent work models, techniques and processes for the use of CDRs in the infrastructure of cellular networks applied in some service for the management of Cities.

Exclusion criteria

Studies that use other technologies (GPs, bluetooth, wifi, etc) from the cellular environment ecosystem, other than through CDR analysis, to provide smart services in cities

Methods

Level 1 - automatic execution of the search strings
Level 2 - which applies the inclusion and exclusion criteria. In the last iteration
Level 3 - Manual reading and inspection models to assess whether the paper fits within the scope of answering the research questions (RQ1, RQ2, RQ3).

TABLE I
QUANTITATIVE RESULTS

Search engines	Level 1	Level 2	Level 3
IEEEXplorer	28	8	6
Scopus	241	154	56
ACM Digital Library	35	21	3
Web of Science	15	8	7
Total	**319**	**191**	**72**

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Quantitative Results

Fig. 2. Number of papers per axles from ISO 37122

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Quantitative Results

TABLE II
SYSTEMATIC MAPPING ABOUT SOLUTION USING CDR TO SMART CITIES

Axles from ISO	Papers 2019	2020	2021	2022
Economy		[10]		[11]
Environment	[12], [13]	[14]	[15]	[16], [17]
Health		[18]	[19]–[21]	[22]
Social		[18], [23], [24]	[25], [26]	
Safety			[27]	[28]
Culture	[29]	[30]		
Transportation	[31]–[38]	[39]–[45]	[21], [25], [26], [46]–[50]	[51]–[58]
Telco.			[59], [60]	
Urban Planning	[31], [34], [61]–[64]	[39], [44], [65]–[70]	[46], [60], [71]–[77]	[51], [52], [78]–[85]
Total	15	20	21	21

*More than **75%** of mapping belongs to the **Transport and Urban Planning** axis (54 of 72 – excluding the repetition axles from the same paper)*

Qualitative Results - Transport

The transport axis analyzed in this review of the papers highlights common aspects in most cases according to (K. CHIN at el,2019), which aims to develop methods for detecting fine-grained transport modes using cellular signaling data (CSD) and compares their performance using ground truth data. The study focuses on modes such as subway, commuter train, tram, bike, (private) car, and walking. The goal is to adapt GPS-based transport mode detection methods to the less accurate and less frequent CSD data and evaluate their effectiveness in analyzing results obtained from this new data source.

Qualitative Results – Urban Planning

The Urban Plan axis analyzed in this review of the papers highlights common aspects in most cases. For example, an important feature is to develop methods for assessing the performance and degree of activity in urban spaces using spatial and telecoms data (R. DOORLEY et al.,2019). Telecoms data are utilized to identify dense and persistent clusters of urban activity, and an Inhomogeneous Poisson Process model is employed to understand the relationship between these occurrences and various features of the urban environment

Qualitative Results – Others axles

Education, Energy, Finance, Governance, Housing and Agriculture.

For the others, we have the following findings:

- Environment: Portray the use of CDR to support decisions in the face of natural or technological disasters .
- Safety: Use CDR for models to detect behaviours that are related to criminal activities.
- Economy: Portray issues related to analysis of the best strategies to increase business, be it analysis for Churners prediction.

Conclusion

We conducted a literature review using specific protocols, criteria for selecting studies, data extraction, and synthesis. Out of the 72 papers chosen, which covered 9 aspects of 19axles from ISO 37122, and transportation and urban planning were the most significant dimensions.

Using CDR data raises ethical considerations, such as data ownership, consent, and potential biases. Integrating CDR data with other datasets and systems used in smart cities can be a significant challenge, including data format heterogeneity and large-scale and high-speed data for smart city environments. Ensuring interoperability between different data sources and platforms is crucial to extract meaningful insights and facilitate effective decision-making.

Aspects	Transporte	Planejamento Urbano
CDR	x	x
ML	x	x
Data aggregation	x	x
Cluster Zones	x	x

Next Steps

1. *Describe COVID case for origin-destination mapping using CDR*

1. *Built a internal SANDBOX inside tellecommunication company to elaborate origin-destination points to use in smart-cities scenarios*

THANKS

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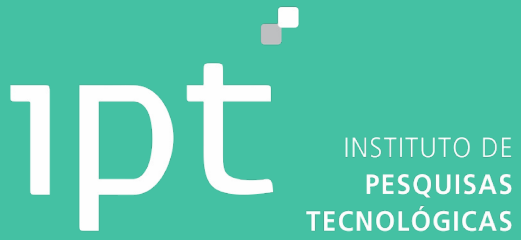
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