Crowdfunding Assisted Cellular System Analysis and Application

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Abstract. In this paper, a novel crowdfunding assisted cellular system analytical (CCSA) scheme is designed. Its basic idea is that mobile terminals collect cellular system related data from different telecom operators continuously, including signal strength, signal quality, data rate, delay etc. Mobile terminals automatically report the collected data to the analytical system periodically. Then, the analytical system analyses the performance and competitiveness level among telecom operators, as well as seeking the problem area for each telecom operator. Compared to driving test (DT) and call quality test (CQT), the CCSA scheme can save the capital expenditure (CAPEX) and effectively analyse the user experience in the cellular system.

Keywords: Cellular system · Mobile terminal · Crowdfunding · APP

1 Introduction

In the past decade, mobile internet experiences fast developments and popularization [1, 2]. The mobile internet reshapes the traditional inter-personal communication and effectively promotes the resources integration in the society [3, 4]. In the mobile internet era, a series of techniques (e.g., big data, data mining, deep learning etc.) become the driving force of enterprise transformation [5, 6]. These techniques are also key to industry upgrading in many traditional industries.

For telecom operators, the big data analysis is vital for mobile cellular system operation and optimization [7, 8]. Employing big data analysis, telecom operators can be aware of user preference, service feature, system performance, terminal characteristics [9, 10]. In this way, telecom operators can grasp the service/operation problems and system development trends [11, 12]. Then, telecom operators can put forward the solution to these service/operation problems, thus continuously improving the Quality of Service (QoS) and providing relevant measures for the cellular system operation [13, 14]. In the traditional cellular system performance analysis, acquiring other telecom operator's data is difficult with high cost, as well as deviation from the user's real perception [15, 16]. This paper tries to address above mentioned problems and designs a novel crowdfunding assisted cellular system analytical (CCSA) scheme. Initially, application (APP) equipped in mobile terminals collect cellular system related data from different telecom operators continuously. Then, mobile terminals automatically

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report these collected data to analytical system periodically. Finally, the analytical system analyses the performance and competitiveness level among telecom operators, as well as seeking the problem area for each telecom operator.

2 Crowdfunding Assisted Cellular System Analytical Scheme

2.1 System Architecture

The basic structure of the proposed crowdfunding assisted cellular system analytical scheme is shown in Fig. 1. The CCSA scheme has two characteristics. The first characteristic is the active data acquisition. For a specific geographic area, mobile terminals and APP periodically collect both the system related data and the service related information. Then mobile terminals and APP report these data to the background server for storage. These collected/stored data can be used in the optimization supporting system and planning & supporting platform etc. The second characteristic is to seek the cellular system problem interactively. The CCSA scheme employs user's data to assess the cellular system and find the problem.

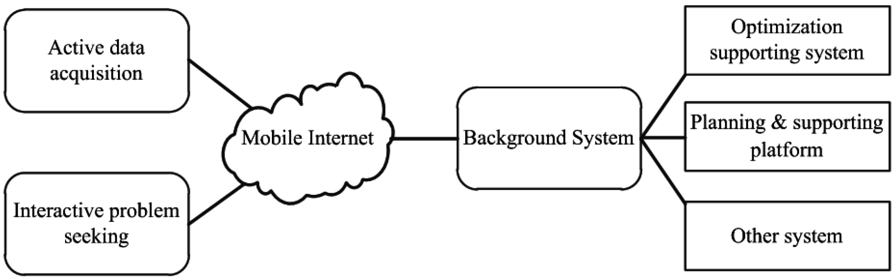

Fig. 1. Basic structure of the CCSA scheme

2.2 Key Indicator

The mobile terminal, especially the smart phone, can be regarded as an integrated sensor system, as well as a comprehensive information processing system. From the perspective of information collection, a smart phone can be regarded as an integrated sensor system. In addition to detection of the wireless environment information, the smart phone also integrates Global Positioning System (GPS), gyroscopes, light sensors, distance sensors, gravity sensors, magnetic sensors, acceleration sensors etc. [9]. Based on these sensors, the smart phone can perceive and record a large amount of information. Based on the Application Programming Interface (API) of mobile terminal operation system, developers can access to the public resources of the mobile terminal, as well as access to the user's information. A series of information can be collected via the API, such as phone number, signal strength, network condition, time information, camera condition, accelerometer information, location information etc. Hence, API also brings the opportunity of comprehensive analysis. From the perspective of cellular system analysis, we mainly collect the following data:

(1) 2G, 3G, 4G mobile system basic information: Cell identification (CI), location area code (LAC), IP address, network identification etc. [17].
(2) User location information: Longitude, latitude, altitude etc.
(3) Wireless environment information: Received signal level (RxLev) in 2G, received signal code power (RSCP) in 3G, reference signal received power (RSRP), signal to interference plus noise ratio in 4G [2, 4].
(4) User perception information: Uplink data rate, downlink data rate, delay etc.
(5) Terminal related information: International mobile subscriber identification number (IMSI), international mobile equipment identity (IMEI), terminal brand etc.

2.3 Key Technology

Data collection is the first step of the CCSA scheme, as shown in Fig. 2. Some service related characters can only be collected when the user undergoes services. In order to drop the worthless raw data, the data pre-process is implemented.

Fig. 2. Data collection and pre-process procedure

2.3.1 Device Collection

Device collection gets data from the operating system APIs. Appropriate APIs are chosen and packaged to Software Development Kit (SDK). And then certain logical operation is implemented to get the final results. This can be applied to Android operation system [18].

2.3.2 Service Collection

Some data are collected when users undergo the service, such as user data volume, service speed, time delay. Actually, most of the perceptive indexes are collected in this stage. Downlink speed and uplink speed are calculated as (1) and (2), respectively. In addition, the APIs involved are listed in Table 1 [18].

$$Speed_{downlink} = \frac{dataVolume_{downlink}}{\Delta \text{time}} \quad (1)$$

$$Speed_{uplink} = \frac{dataVolume_{uplink}}{\Delta \text{time}} \quad (2)$$

Table 1. APIs for speed calculation

Description	Method name	Purpose
Get current timestamp	System. currentTimeMillis()	To calculate time
Received bytes	getTotalRxBytes()	To calculate downlink speed
Sent bytes	getTotalTxBytes()	To calculate uplink speed
Received byte in mobile network	getMobileRxBytes()	To calculate downlink speed in cellular network
Sent byte in mobile network	getMobileTxBytes()	To calculate uplink speed in cellular network

2.3.3 Property Association

For further analysis, we associate the data with social properties, such as geographic information [19, 20]. Based on GPS information, the geographic association is utilized to classify points to certain areas, including the linear scene and the polygonal scene. As shown in Fig. 3, the beam method is applied to decide whether a point is in a certain polygon. The main idea is that: if the point is in the polygon, there are odd crossover point between the beam of point and the polygon; otherwise, there are even crossover points.

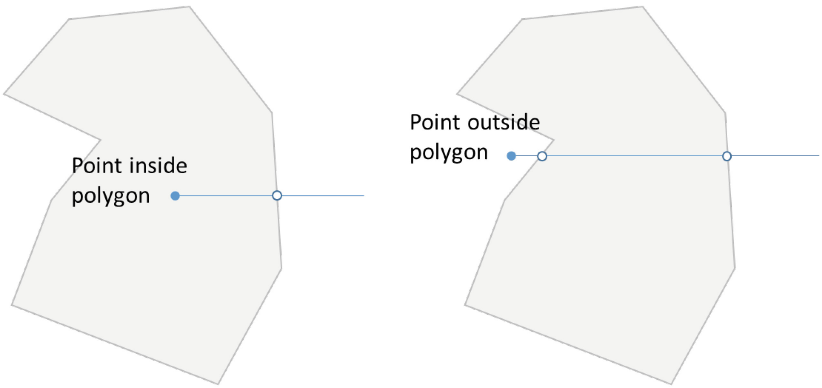

Fig. 3. Beam method to judge whether a point is in a polygon

Besides, the CCSA scheme needs commercial channels to popularize the SDK, in order to release the SDK to more phones. Ordinarily, there are several ways to popularize the SDK. To develop and operate an application is a direct way, however, the cost is high. Another way is to develop an application service platform, where statistic analysis for application operation is supplied for free. When the SDK from our service platform is bundled in any APP, the app plays a role as a data collector, continuously supplying user data. At the same time, the SDK obtains huge number of data in mobile terminals.

3 CCSA Scheme Application

3.1 Main Application Aspects

The crowdfunding data can be applied in the following four aspects:

(1) Network Analysis: The crowdfunding data contains the information of operators' network parameters and network signal. We can get the network overall performance from different dimensions and be aware of the gap with competitors, so that we can provide data support for network construction and optimization [21, 22].
(2) User Analysis: The crowdfunding data also includes the user information, such as the user phone number, IMSI etc. [19]. Based on different user groups' service perception, we can focus on customer care and support for the VIP subscribers.
(3) Terminal Analysis: The crowdfunding data also contains the terminal information. Therefore, we can analyze the terminal performance in the network, thus to provide support for terminal marking [5].
(4) Other Analysis: In addition to the analysis of the cellular system, the crowdfunding data analysis can also be used in WIFI network evaluation.

3.2 Network Competitiveness Analysis

It is beneficial to carry out cellular system competiveness analysis based on the crowdfunding data, leading to a wider coverage, a lower cost of data acquisition and a more accurate user perception. Compared with traditional DT/CQT methods, the CCSA scheme has obvious advantages to provide effective supports for network development and construction.

3.2.1 Network Competitiveness Analysis Process

The overall process for dealing with the smart phone APP data is shown as Fig. 4.

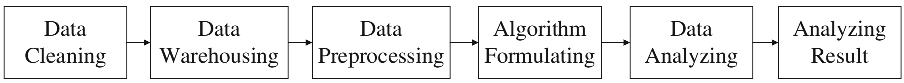

Fig. 4. Overall process for dealing with the smart phone APP data

The first and second step are data cleaning and data warehousing, respectively. The data that is out of reasonable range or incomplete ones should be cleaned [23]. Besides, each sample point should contain the required fields for analysis. After data cleaning, the structured data are saved in a database for subsequent statistical analysis.

The third step is data preprocessing. The main work of data preprocessing is to decide each sample data point's features, e.g., the terminal brand model belonging, the operator belonging, the network type belonging and the geographic area belong.

The fourth and fifth step are algorithm formulating and data analysis, respectively. Network competitiveness analysis can be carried out in two dimensions. The first dimension is from different aspects (such as the network coverage, delay, service speed rate) to set up a single parameter evaluation algorithm to reveal single network parameter competitiveness among telecom operators. The second dimension is to set up an operator network competitiveness comprehensive evaluation system, the overall comprehensive score of network competitiveness for each operator can be obtained.

In the last result demonstration step, the result of the single parameter and comprehensive network competitiveness can be demonstrated in various forms such as diagrams, maps and so on.

3.2.2 Single Parameter Network Competitiveness Analysis

The single parameter network competitiveness analysis can be divided into five aspects: the network scale competitiveness analysis, the network coverage competitiveness analysis, the network quality competitiveness analysis, the network speed rate competitiveness analysis and the network service time delay competitiveness analysis. Each can be processed from different time granularity (month/quarter/year) and geographical granularity (provinces/cities/scene/grid).

(1) Network Scale Competitiveness Analysis
Operator network scale competitiveness analysis consists of three aspects: the number of users, sampling points and cells. These aspects can reflect the operators' user market share distribution and network size, as exemplified in Fig. 5.

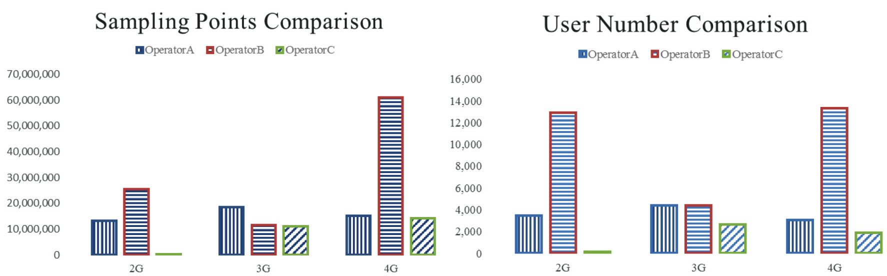

Fig. 5. Exemplified results of network scale competitiveness

(2) Network Coverage Competitiveness Analysis
Coverage competitiveness analysis can be evaluated via good coverage sample point ratio and 4G network sample point ratio. Percentage of good coverage sample point can be used as indicators for evaluation of 2G (RSSI), 3G (RSCP) and 4G (RSRP) coverage performance, which is defined as: the number of sample point that its signal strength is greater than a certain threshold accounted for the proportion of all sampling points, as shown in Fig. 6. While the 4G network sample point ratio is used to evaluate operators' 4G signal coverage competitiveness, which can be defined as: the sample points generated by 4G users in the

4G network users in the 4G network accounted for the proportion of total sampling points of these users in 2/3/4G.

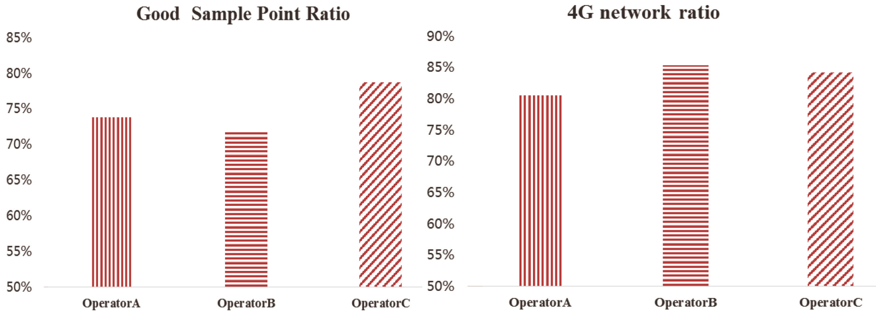

Fig. 6. Exemplified results of network coverage competitiveness

(3) Network Quality Competitiveness Analysis
Operator network quality competitive analysis can be evaluated via good signal quality sampling point ratio. 4G good signal quality sampling point ratio is defined as the number of sample point that its signal quality SINR is greater than a certain threshold accounted for the proportion of all sampling points.

(4) Network Speed
Download (downlink) speed and upload (uplink) speed are applied to evaluate the operator competitiveness of speed, as exemplified in Fig. 7. The download speed and upload speed are affected by the behavior of users.

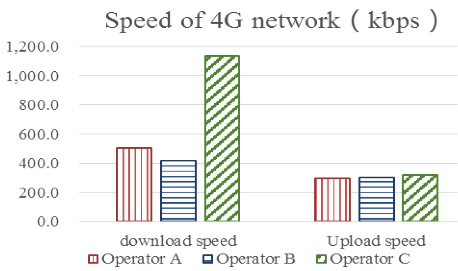

Fig. 7. Results of speed in 4G

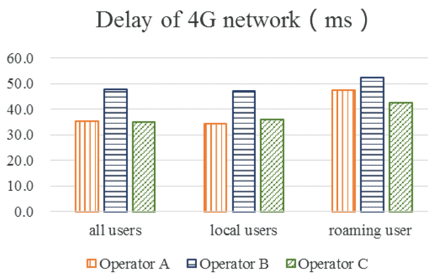

Fig. 8. Results of delay in 4G

(5) Network Delay
Network delay is defined as the delay of ping to some typical website, such as SINA, TAOBAO, YOUKU, IQIYI and etc., which is designed according to specific requirements. Network delay includes the delay of each website and the average delay of all websites, which measures the level of user perception immediately, as exemplified in Fig. 8.

3.2.3 Global Competitiveness Analysis of Network

In the above subsection, we evaluate the competitiveness of each operator by its coverage, interference and perception respectively. However, to evaluate the competitiveness of each operator synthetically, we propose an analysis system based on Analytic Hierarchy Process, which is shown in Table 2.

Table 2. Operator network competitiveness evaluation system (4G)

	Cover		Interference	Perception		
Index	Good sample point ratio	Proportion of 4G users in 4G network	Signal quality	Download speed	Upload speed	Delay
Weight	30%	10%	10%	20%	10%	20%

The score of each index is computed as (3).

$$Score = \frac{x_i}{max(\mathbf{x})}(i = 1, 2, 3) \tag{3}$$

Where x_i is the value of each index and $\mathbf{x}$ is a one-dimensional set composited by three operators. Specially, the score of delay is as (4). A higher score reflects a less delay.

$$Score_{timedelay} = \frac{\min(\mathbf{x})}{x_i}(i = 1, 2, 3) \tag{4}$$

The competence of each operator is computed as (5).

$$\begin{aligned} Competence_{LTE} &= Score_{\text{coverage}} \times k_{\text{coverage}} + Score_{4Gratio} \times k_{4Gratio} \\ &+ Score_{upspeed} \times k_{upspeed} + Score_{downspeed} \times k_{downspeed} + Score_{timedelay} \times k_{timedelay} \end{aligned} \tag{5}$$

where *Score* is the level of each index and *k* is the weight of each index.

Based on practical data and requirements, we present an example result in Table 3. The result of operator competitiveness evaluation via the CCSA scheme shows that Operator B (0.93) > Operator C (0.82) > Operator A (0.81). This means the network of Operator B is the best while the Operator C and the Operator A have similar competition level.

Table 3. 4G network of operator competitiveness evaluation (Example)

Index	Good sample point ratio	Proportion of 4G users in 4G network	Download speed	Upload speed	Delay	Competence
Weight	30%	20%	20%	10%	20%	
Operator A	0.88	0.82	0.80	0.58	0.82	0.81
Operator B	1.00	0.98	1.00	1.00	0.67	0.93
Operator C	0.90	1.00	0.58	0.35	1.00	0.82

4 Conclusion

In this paper, we design a crowdfunding assisted cellular system analytical (CCSA) scheme, including its framework, mainly-used indicators, key technologies as well as channel expansions. In terms of application, we introduce the content, application of direction, flow and case of this system. As a novel method, the CCSA scheme changes the traditional mode of network analysis, expands the category of network analysis, benefits the network quality of network and expands the range of users. In the future, the contents of the analysis would be further enriched, and the collection of data would be more normalized and persistent. In addition, the combination of data from the OSS and the BSS domain will be enhanced and the CCSA scheme will be constructed to realize normalizing analysis and application.

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