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Enhanced Fingerprinting and Trajectory Prediction for IOT Localization in Smart Buildings

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ABSTRACT- **Location service is one of the primary services in smart automated system of Internet of Things (IoT). A localization approach is proposed that utilizes the neighbour relative received signal strength. It is used to build the fingerprint database and adopts a Markov-chain prediction model to assist positioning. In LNM scheme, the history data of the lower the unpredictable signal fluctuations in a smart building environment.**

***Index-Terms*-Fingerprint, Internet of Things (IoT), Markov chain, mobile positioning, smart buildings.**

I. INTRODUCTION

Internet of Things (IoT) incorporates concepts from pervasive computing and enables interconnections of day objects equipped with ubiquitous intelligence, which becomes an integral part of the Internet. IoT has gained much attention from practitioners and researchers around the world, and spawned a wide variety of smart automated systems, such as smart buildings, smart homes, smart factories. IoT is opening tremendous opportunities for novel applications that promise to improve the quality of our lives. IoT has gained much attention from researchers around the world. Real RSS fingerprints at any location always change with time. Besides, considering the hardware differences of mobile devices (e.g., smart phones, tablets, mobile robots, mobile smart objects), the localization system need to access database storing a great amount of data, which will take plenty of time. In this paper we propose a novel localization method (LNM) based on neighbour relative RSS (NR-RSS) and Markov-chain prediction algorithm, which mainly utilizes fingerprint-based technology and Markov-chain model to provide higher accuracy of localization with lower calibration requirement.

II. RELATED WORK

Recently, wireless localization has become a focused research topic in the IoT context and a variety of solutions have been proposed. The IoT indoor localization approaches can generally divided into two categories: passive method and active method. In the passive localization approach, the tracked person (even a smart object) does not carry any electronic device and actively participate in the localization process. In the active localization case, tracked person (even a smart object) carries a physical electronic device, which can collect and process some information and send results to a localization server for further processing.

III. PRELIMINARY OF FINGERPRINTING-BASED LOCALIZATION

In this section, we present the typical fingerprint-based IoT localization algorithms for smart buildings and analyze their shortcomings and limitations. It consists of two phases, online and offline phases. These fingerprint-based localization systems usually take ARSS values as the fingerprint. The main challenge is the fact that the techniques are vulnerable to environmental dynamics and heterogeneous dynamics for the fingerprint-based localization systems, the construction a robust and precise radio map is crucial. But there are two major issues limiting the accuracy of radio map. To overcome challenges, NR-RSS, the difference of RSS to build fingerprint

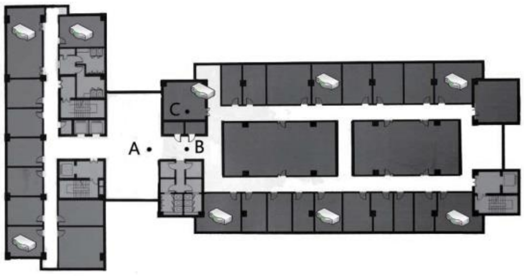


Fig. Floor plan of localization environment.

As the environmental dynamics at close positions are considered almost the same, the influence of environment on RSS positional, these is nearly identical, these RSS values tend to change synchronously.

Unlike typical fingerprint-based localization systems, we introduce a novel technique adopting NR-RSS to overcome the mentioned weakness. To verify the effectiveness of theory analysis, we performed the following experiment by collecting RSS values, points A and B.

Algorithm 1: NR-RSS Matching Localization Algorithm

1: Initialize (GSL)

2: **loop**

3: **if** movement **then**

4: Compute CND-RSS

5: Match CND-RSS with NR-RSS fingerprints

6: **if** *Dmin* > *δ* **then**

7: PGSL

8: **else**

9: Localization according to *Dmin*

10: **end if**

11: **else**

12: current location = last location

13: **end if**

14:end

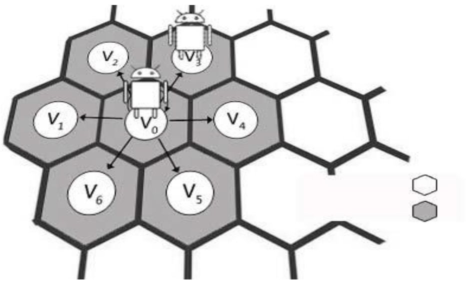


Fig. Object's state transition of motion.

IV. MARKOV- PREDICTION MODEL

Fingerprint-based localization systems must scan the surrounding RSS on each positioning at online localization phase. It is a high-energy-consuming operation for smart objects such as smart phones. It is more efficient to predict the object's movement by means of mathematical models. Thus, we apply the Markov-chain model to conduct object's trajectory analysis, which can reduce the energy consumption. In the Markov chain mode, localization object is likely to conduct object's trajectory analysis, which can reduce the energy consumption. In addition the probability of object's movement can be obtained through the process of collecting and training. For example, an object has to go directly to know a location, current location and the probability of movement can be combined to predict the next location. In practical application, more history data are collected to improve the accuracy of further prediction. In our evaluation experiment, enough history records are collected to start predicting.

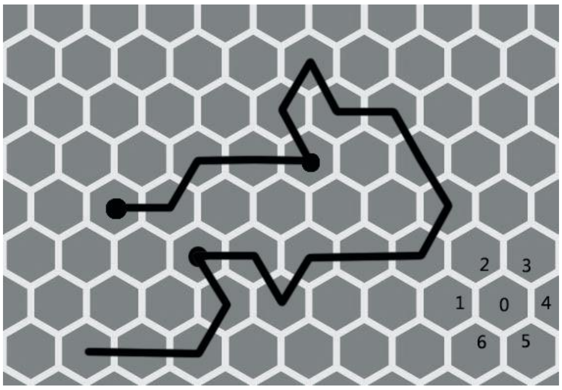


Fig. Random pedestrian's trajectory.

MARKOV-PREDICTION LOCALIZATION

At the begining of the NR-RSS matching localization phase,there is a necessity for scanning the surrounding WiFi signals for each localization estimation process.This is quite a high-energy consuming and time-consuming operation for mobile devices.To prevent the Markov prediction localization from causing the accumalotor error,the NR-RSS match localization needs to be executed to verify the accuracy of markov prediction localization.

Algorithm 2: Markov-Prediction Model Algorithm

1: **loop**

2: **if** History records <C **then**

3: NR-RSS Matching Localization

4: History records++

5: **end if**

6: **end loop**

7: **if** History records >= C **then**

8: Build Markov Prediction Model(MPM)

9: Localization by MPM

10: **end if**

11: **if** MPM localization result == NR-RSS localization result **then**

12: History records++

13: **else**

14: **if** NR-RSS localization result is the neighbour of the last location **then**

15: Localization result== NR-RSS localization result

16: **else**

17: Run PGSL to get localization result

18: **end if**

19: History records—

20.end if

PERFORMANCE EVALUATION

This section discusses the results of real experiments to evaluate the performance of our proposed LNM. First, experimental test bed and the context of experiment are introduced in detail. Second, we evaluate the performance of the proposed algorithm under heterogeneous devices against other well-known algorithms.

TABLE III

SMARTPHONES CONFIGURATION INFORMATION

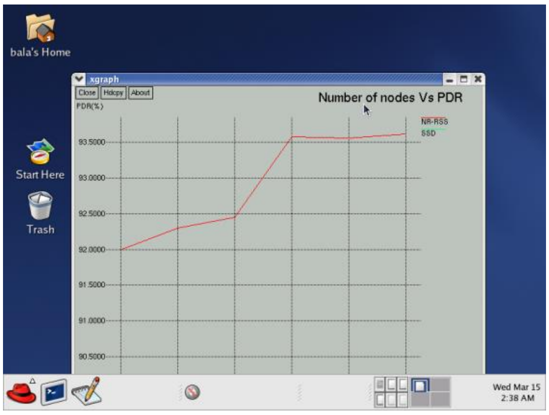
Smartphone (m)	Galaxy S3	Mi3	Ascend P6	MX2
WiFi	802.11 n/b/g	802.11 n/b/g	802.11 n/b/g	802.11 n/b/g
OS	Android4.0	MIUI V5	Android4.2	Flyme2.0
CPU	1.4GHz	1.8GHz	1.5GHz	1.6GHz
RAM	1GB	2GB	2GB	2GB

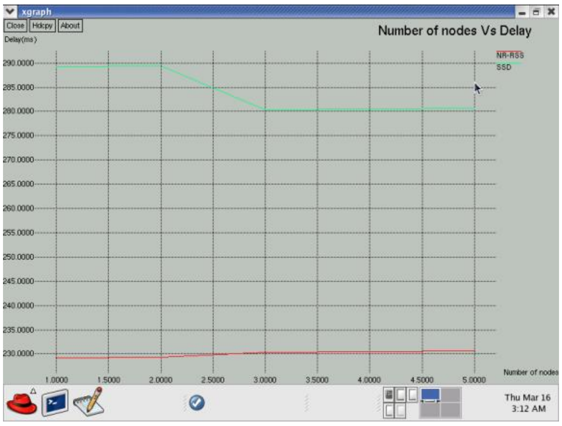
EXPERIMENTS

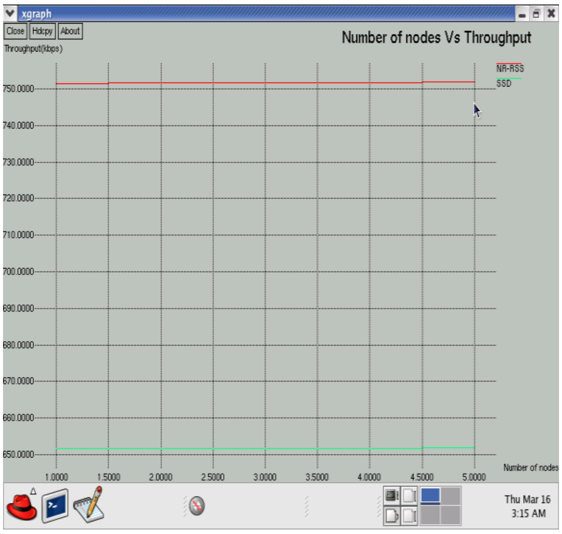
The accuracy of our localization system is significantly influenced by various systems parameters. To obtain an ideal location estimation, we should first find out the optimal parameters values. Among them, cell radius has a significant impact on the accuracy of localizing. First, each RSS value corresponding to a cell is used to calculate the NR-RSS value. Second, in MPM, seven different statuses of the object movement are expected to locate at the adjacent cells. As we localize the cell instead of specific geographic coordinates, the cell spacing will impact the location error and correct rate significantly. At last, we compare the performance of LNM and three other well-known systems: RADAR, Zee and WILL. these indoor localization systems are quite classical or a relatively new positioning solution.

V. PROPOSED SYSTEM

Fingerprint based localization systems must scan the surrounding RSS on each positioning at online localization phase. It is a high energy consuming operation for smart objects such as smart phones. The Markov-chain model is applied to conduct object's trajectory analysis, which can reduce the energy consumption. The proposed fingerprint radio map building and localization techniques based on neighbour relationship. This technique provides robust and stable localization accuracy against device heterogeneity and environmental dynamics, which ensures the efficiency of location. It has the advantage of low cost, low complexity, accurate detection.







VI. CONCLUSION

In this paper, we have proposed and evaluated a novel method, named LNM, which uses Nr signal fingerprint and Markov chain for localizing, in smart building environment. For future work, we will evaluate other mobile devices such as aeroterrestrial drones (e.g., WiFiBot and Parrot) in complex buildings, as such smart objects will be used in future smart buildings for supporting many activities (cleaning, emergency, disabled people support, and so on).

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