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研究課題名（和文）ネットワークとユーザの状況に対応する自律的なIoT・M2Mプラットフォーム構築

研究課題名（英文）Autonomous IoT(M2M) Platform based on Network and User Situations

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研究成果の概要（和文）：既存のInternet of Things（IoT）・M2Mの研究では、ユーザに近いローカル側では状況認識と管理、タスクの最適化的な分配の手間を省くが、大量データの送受信による混雑、サービスレスポンスの遅延等の問題がある。これらの問題を解決するため、
本研究は、（１）ユーザの状況を管理や認識するアルゴリズム、（２）ユーザに近いデバイスを利用し、タスクの最適化的な配分する方法、（３）災害時ユーザやネットワークの状況により通信ネットワークを最適化する方法などを開発しました。開発した技術を利用し、高齢者ケアサービスや災害時効率的に連絡手段として、活用することを期待してます。

研究成果の概要（英文）：Current researches on Internet of Things (M2M) will meet response delay problem when transmitting huge data from sensors and terminals in the world, without considering user and network situations, and how to optimize task allocation among IoT devices.
In this project, we focus on the above research issues and propose (1) algorithms to recognize and manage situations at both user and network sites, (2) optimization methods to efficiently allocate tasks among IoT devices nearby the user, (3) optimization methods for emergency communications network after disaster occurring based on user and network situations. The developed techniques are expected to enhance services for elderly care and emergency response in the future.

研究分野：　Computer Network

キーワード：　Internet of Things　Computer Network　Emergency Communications　Elderly Care　Situation Recognition

１．研究開始当初の背景

IoT (Internet of Things)・M2M はユビキタスコンピューティングとクラウド·コンピューティングを融合し、幅広い応用分野を持ち、インターネットの実世界への発展形である。IoT・M2M の世界動向に関する調査をした結果、IoT・M2M 技術の発展のため、以下の三つのチャレンジがある。

チャレンジ１：Internet of Things (IoT)・M2M に資源の組織・管理、高信頼のリアルタイム伝送;
チャレンジ２：ローカルクラウド側とクラウド側のタスクの最適化的な分配
チャレンジ３：状況の迅速で正確な検知
IoT･M2M における状況の検知･推定、及び、サービスの発見は非常に重要な研究課題として多くの注目を集めている。

２．研究の目的

本研究の目的は、今までの IoT・M2M の枠組みを打破し、新たな 3 つの Tiers の IoT・M2M アーキテクチャを提案し、ネットの状況を解析・予測・推定を可能し、自律性・高い信頼性・レスポンスの迅速性を持つ IoT・M2M を構築することである。

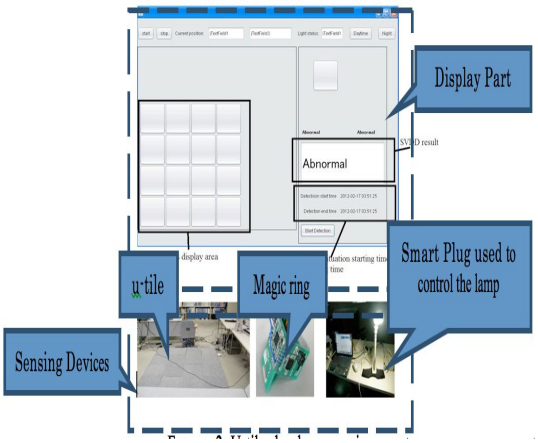
具体的に、
①ユーザ状況を自動的に認識し、自律的に管理するため新たなメカニズムの設計。
②周囲のモバイルデバイス等を利用し、迅速的に反応できるローカルクラウドの構築。
③クラウドで、ユーザに適切なサービスを提供するため、様々なユーザからのデータを分析する。さらに、短応答時間、高効率に通信するため、ユーザ、ネット等の状況によるネットワークを解析する。

３．研究の方法

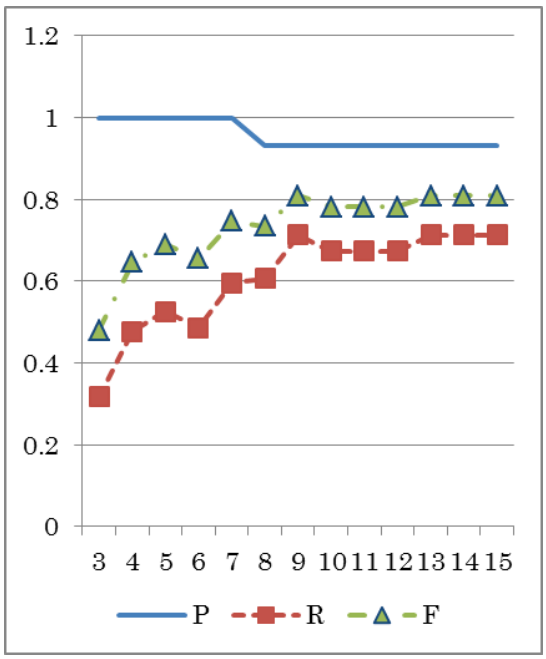
本研究は以下のサブ研究テーマに分かれて研究をしてきた。
具体的に、
①ユーザ状況を自動的に認識し、自律的に管理するため新たなメカニズムの設計。
②周囲のモバイルデバイス等を利用し、迅速的に反応できるローカルクラウドの構築、またはタスクを最適化する方法の開発。
③クラウドで、ユーザに適切なサービスを提供するため、様々なユーザからのデータを分析する。さらに、短応答時間、高効率に通信するため、ユーザ、ネット等の状況によるネットワークを最適化する。

４．研究成果

(1) A middleware for managing situations was designed, to prompt the development of context-aware services. It is characterized by its ability of situation-oriented, paying attention to relations among users (and situations as well) and smart objects around. Eventually, following issues were solved: (a) a method for detecting (i.e., being aware of) a specific situation, and triggering corresponding service; and (b) an algorithm for conflict situations/contexts management. A diagram of situation state transition (DSST) was proposed to specify states of a situation. A set of situation-oriented ECA rules are presented to reason the situations' states based on sensed data. Policies based on DSST for resolving conflicts were also given. The experiment results demonstrate the feasibility of proposed method, and the performance of proposed situation-oriented policies. The research results are published in [1][6].



(a) Implementation of the System



(b) Precision of Detection

Fig. 1 Implementation and Some Evaluation Results to Detect Abnormal Situations in Researches (2)

(2) Elderly care is a very serious social problem in many countries, especially in advanced countries, such as Japan, Korea, USA, and Singapore. To take care of elderly people, first we should clearly understand their situations and support them based on each situation. Abnormal activity detection is a particularly important task, especially in specific situations, e.g., sleeping or going to the bathroom. Based on some abnormal activities, some kinds of diseases may be predicted. However, detecting abnormal activities in a real-time situation is a critical research problem. To solve this problem, we propose a situation-aware abnormality detection system based on support vector data description (SVDD) for elderly people. First, a sensing system is proposed to detect the details of a person's situation. Then, we discuss various features that are analyzed and designed for each situation. Then, a method to detect abnormal activities in a situation based on SVDD is presented. To show the performance of the method, an evaluation is performed. The results are published in [2][7].

(3) We propose a novel three-layer architecture consisting of wearable devices, mobile devices and remote cloud for code offloading. Specifically, we offload a portion of computation tasks from wearable devices to local mobile devices or remote cloud such that applications even with heavy computation load can still be upheld on wearable devices. Furthermore, considering the special characteristic and requirements of wearable devices, we investigate an offloading strategy with a novel just-in-time objective, i.e., maximizing the number of tasks that should be executed on wearable devices with guaranteed delay requirements. Because of the NP-hardness of this problem as we prove, we propose an efficient algorithm based on Genetic Algorithm (GA) to solve it. Finally, extensive simulations are conducted to show that our proposed algorithm significantly outperforms other three offloading strategies [3].

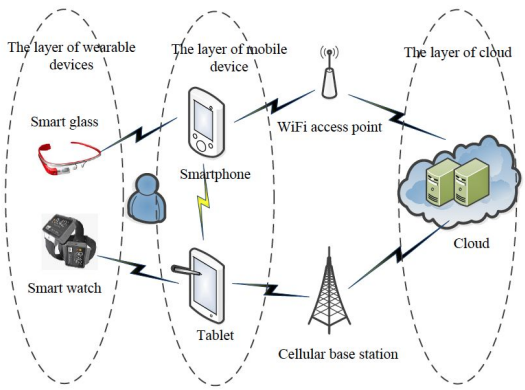


Fig. 2 Model of Three-layer Architecture for Researches in (3)

(4) It is a critical research problem to quickly reconstruct a communication system for safety confirmation and information transfer after a disaster. One resolution is to deploy mobile mesh routers (MMR) or mobile base stations in the disaster area to guarantee the connection of users. Due to special factors after a disaster, however, it is still a challenge to find an optimal deployment of MMRs to maximally satisfy users while ensuring a fluent and reliable communication network. For example, the distribution of users and communication demands becomes unbalanced in a disaster area. We focus on the above problems by considering the special requirements after a disaster, and then we propose a communication-demand-oriented deployment method and a global-data-traffic routing optimization method for a disaster. We implemented the proposed methods and evaluated them in Matlab and NS3. Through the evaluation, we show the feasibility, performance and scalability of the proposed methods[4][8].

Fig. 3 Optimization of Emergency Communications Network based on Situations in Researches (4)

(5) We propose a 3D localization method for understanding survivors/corpses' location situations based on WSN. It mainly consists of two stages. In the first stage, a draft location is calculated based on some beacon nodes put around the collapse, and then the 3D localization is computed in the second stage based on a mobile beacon node moving along an equilateral triangle rail. Meanwhile, to decrease instantaneous fluctuation of RSSIs, we employed Kalman filter in the method to acquire stable RSSIs. Finally, we implement a robot car with a sensor node acting as a mobile beacon node and evaluate the proposed method through experiments in a gym [5].

５．主な発表論文等
（研究代表者、研究分担者及び連携研究者には下線）

〔雑誌論文〕（計　5　件）

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〔図書〕（計　　件）

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○出願状況（計　　件）

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〔その他〕
ホームページ等

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