Autonomic Inferring of M2M-IoT Service-usage from User-Emotion and Environmental Information

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M2M-IoT is an enabling technology for intelligent communication among internet-penetrated smart-devices. An autonomic approach has the potentiality to resolve the increased-complexity of network and service management, raised by M2M-IoT. In this context, we have developed a learning-based Autonomic Network Management System that is capable to recommend personalized services by inferring service-usage from user-emotion and environmental information. We have evaluated the performance of our system through a case-study by an e-mail survey with 77 people (graduate students, lab alumni, school officials) and by a traffic-analysis of smart-devices of 16 lab-members in a working day.

1. Introduction

With the penetration of internet-enabled smart-devices, M2M-IoT is considered to play a major role in today's life. However, it also has posed the challenge of increased-complexity of network and service management, due to the high-demand of personalized services and the arrival of numerous smart-devices. In this context, autonomic network management systems are becoming popular for their self-decision-making ability, by which systems can learn context and enforce network and service-management policy, by keeping human-intervention to the minimum possible level.

Service-usage differs among smart-device users, according to their emotion, environmental information (location, weather, etc.). This is very important for service-providers, who are interested about the popularity of services in maximum number of subscribers.

Therefore, we have developed an Autonomic Network Management System(section 2.1, 3.2) that recommends personalized service by inferring service-usage from user-emotion and environmental information from traffic-analysis and E-mail survey. The system consists of three major modules, An Autonomic Inference Manager (AIM), Smart-Agent and Collection Server. Collection server captures traffic-information (application-usage, location, weather) of smart-device user. AIM uses Psychic inference engine to infer service-usage from survey and traffic-information and then recommends personalized service to users.

We have implemented Psychic Inferring Engine (section 2,3)[1] that finds service-usage preference, discrepancy among user-groups by using Multivariate Gaussian Distribution. We have evaluated the system performance(section 3) through a case study by an e-mail survey with 77 people from 25th February to 25th April, 2013[2] and by monitoring traffic of smart-devices of 16 lab students on the 25th February[3].

2. Proposed Learning-based Autonomic Network Management System

In this section, we describe proposed Autonomic Network Management System (Fig.1), followed by Psychic inference engine.

2.1 System Architecture: Proposed system consists of four major modules, namely smart-agent, collection server, autonomous inference manager (AIM) and Hadoop-based traffic measurement and analysis platform.

User defines choices of interest (COI) through customizer sub-module of smart-agent. COI means emotions (happiness, sadness, relaxation, boredom), locations (work-place, home, subway, etc.), weather (sunny, cloudy, snow, fair, etc.) and time (office-going, lunch, office-closing, evening, etc.) at which they prefer to get service-recommendation.

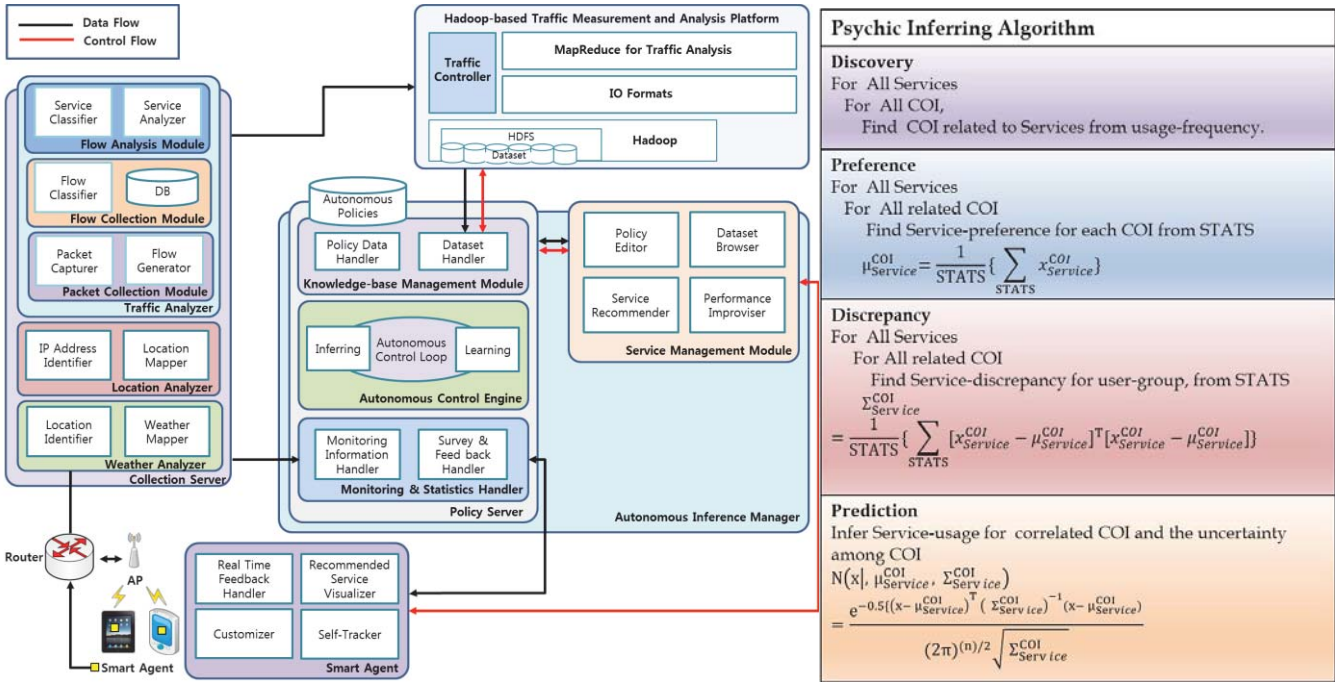

Fig. 1: System Architecture

Then, collection server analyzes traffic to monitor the service-usage (service-execution, usage-time, usage-frequency, etc.), user-location and also present weather at that location.

Hadoop-based traffic-measurement and analysis platform maintains Statistical datasets of traffic analysis and E-mail survey.

AIM maintains service-recommendation policies in Policy server through an Autonomous Control Loop. These policies are autonomous, since system continuously learns to recommend service, by inferring service-usage from statistics of traffic-information and survey. Thereby, an autonomous control loop, based on inferring and learning, is the driving force of this system. Service recommenders visualize recommendations, performance-improvement notifications through service-management module.

2.2 Psychic Inferring Engine: Let us describe Psychic inferring algorithm which is the core of inferring engine.

Discovery: Smart-device users seek personalized service-recommendation for different choices of interest (COI), for example, happiness, sadness, boredom, relaxation, at office, at workplace, in morning, at lunch, etc. Discovery checks for each service (YouTube, KaKaoTalk, Facebook, etc) and finds which COI are related to that service, by using the service-usage frequency. For example, our case-study yields that COI happiness and relaxation are correlated to YouTube-service.

Preference: Service-providers always want to find larger user group (with correlated COI-pair) for specific service. So, Preference finds, for any specific service, common user-group for each COI, separately.

Discrepancy: However, at the same time, service-providers want to be well-aware of the variances of choices in different user-groups. Therefore, discrepancy finds, for any specific service, the variance of any user-group, from the common user-group, for each COI separately.

Prediction: Given preference and discrepancy for specific service and correlated COI, service-provider predicts whether a user-group belongs to common user group or varies from common with some uncertainty.

3. Case Study, Implementation Scenario

3.1 Case-study: In our case-study, at first, we have conducted an email survey [2] among 77 people with questionnaires about their preferred services in different emotions, locations, weather and time, etc. Then, we have conducted traffic monitoring[3] among 16 lab members' smart-devices to observe their preferred services in different parts of the day.

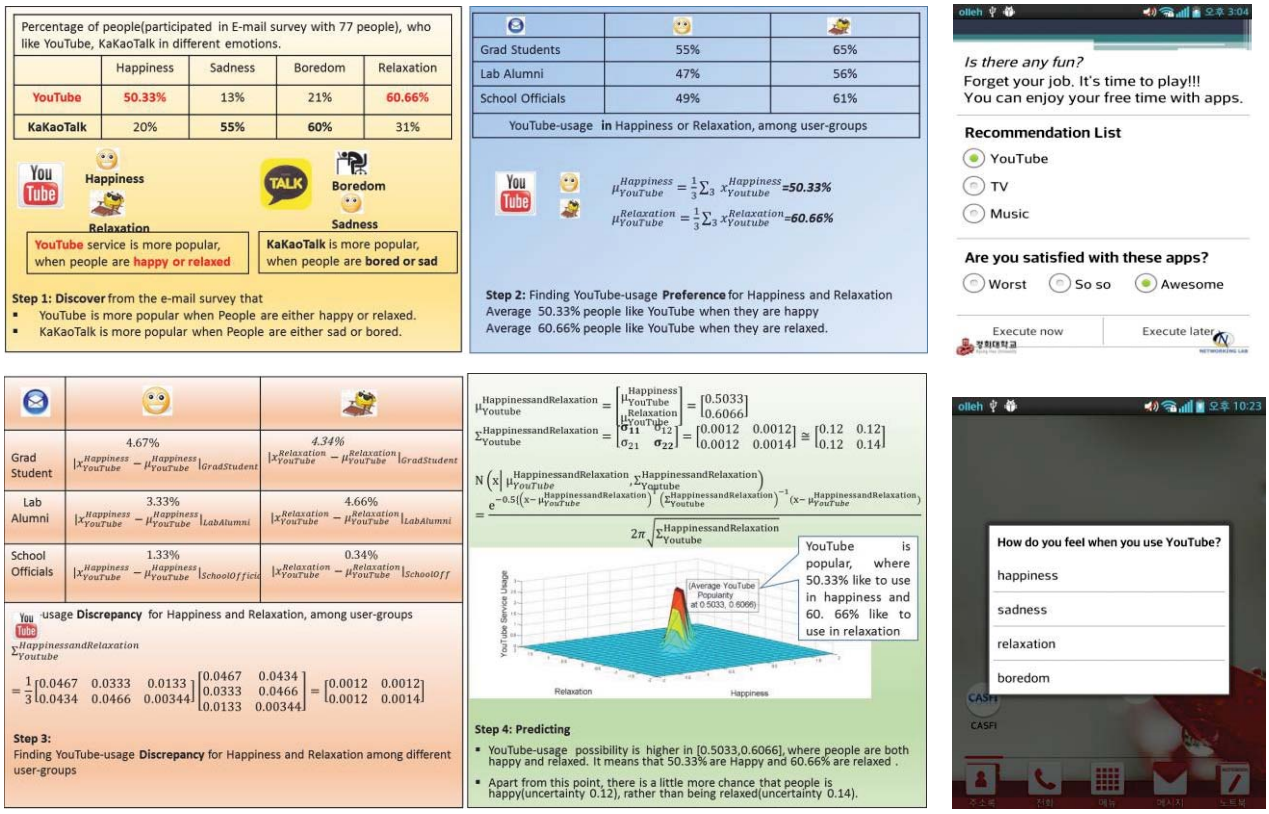

Fig.2: Case study results, followed by Developed Smart-app modules(Recommenation Visualization & Real-time Feedback)

3.2 Development Environment: We have developed Psychic Inference engine in Python 2.7, by using scientific computing libraries, namely Numpy, Scipy. Service Management module is developed with Adobe Flex 4.6-based UI and Graph-plotting API and Python-based Matplotlib API. Smart-agent is developed in Android platform. Collection server is developed in Java by using Jpcap for traffic analysis, KISA WHOIS API for location tracking, Yahoo Weather API for weather analysis.

3.3 Application Scenario: We have considered our system to recommend service in the daily-life of a work-going person. From e-mail survey and traffic analysis, Psychic, recommends services (Fig. 2) on smart-agent of users based on the most-common observations. People generally feel better on the way to work-place and like to listen to music. However, in work-place, they like to browse news, when they generally they feel bored. After day long work, they generally feel tired and prefer chatting in the bus/subway. As soon, as they feel relaxed, they start listening to music. However, at home, they prefer to spend time in social network. Service recommender visualizes also autonomous service recommendation policies for work-going persons.

4. Conclusion

We are now working on learning engine that enables the system to learn the popularity of recommended service from service-usage frequency, usage-time and real-time feedback, etc.

5. Acknowledgement

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6. References

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