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Global IT Research Institute

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Volume. 4 Issue. 2

A Remote User Interface Framework for Collaborative Services Using Globally Internetworked Smart Appliances

Bongjin Oh*, Jongyoul Park *

*Bigdata S/W Platform, *ETRI, 218 Gajeong-ro, Yuseong-gu, Daejeon, 305-700, Korea*

bjoh@etri.re.kr, jongyoul@etri.re.kr

***Abstract*—This paper introduces a remote user interface framework which supports devices to share the UI of their applications with multiple smart devices. The smart devices are internetworked globally through RUI server. Besides that, a virtual IO function is provided to use mobile devices as remote controller. By thus, users can control home networked devices and applications by their smart devices with intuitive UI/UX. The proposed framework provides collaborative application model, APIs of sharing application view and virtual IO emulator.**

***Keyword*— RUI framework, home network, collaborative application, UI migration, Virtual IO**

I. INTRODUCTION

Smart devices, smart phones and smart pads, have become the most familiar appliances with users since those devices were introduced with multi-touch based intuitive user interface. TV is known for the friendliest consumer device to people. It also has evolved to smart device from a typical passive device.

The current TV provides users with various interactive contents augmented from linear services and downloaded from application servers. Moreover, it is not awkward for people to interoperate their smart devices with smart TV for collaboration services [2][5][7][8].

Recently, many researches have been introduced to interoperate the smart devices with other devices such as TV, information appliances and various sensors in home network area [1][3][4][6]. Many RUI (Remote User Interface) standards such as MIRACAST [11], DLNA-RVU [12] and Airplay [13] use streaming protocols to provide remote device control or collaborative services. They have some problems of using too a lot of bandwidth and supporting only sharing of main graphic user interface because they transmit video streams using the sequences of images captured from frame buffer.

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Jongyoul Park was with the Electronics and Telecommunications Research Institute, Daejeon, 305-700, Korea. (e-mail: jongyoul@etri.re.kr).

An HTML5 based collaborative application platform is provided by MOVL UI [14]. It is independent of device platform and based on a cloud server for collaboration services. But it is time consuming for users to connect client applications with host applications. Multiple applications should be installed on smart devices, and users should interconnect the devices by logging into allocated room with room number displayed on TV screen by host applications.

This paper proposes a RUI framework based on sharable GUI to support collaborative services among interconnected smart devices. Virtual IO emulator is also provided to control remote devices using virtualized device controllers.

The rest of this paper is organized as follows. Chapter II describes the overview of the proposed RUI architecture, and a reference implementation of the RUI framework with exemplary RUI services is shown in chapter III. Lastly, we conclude our research briefly in chapter IV.

II. THE PROPOSED RUI FRAMEWORK

A. *Network Configuration of the RUI Framework*

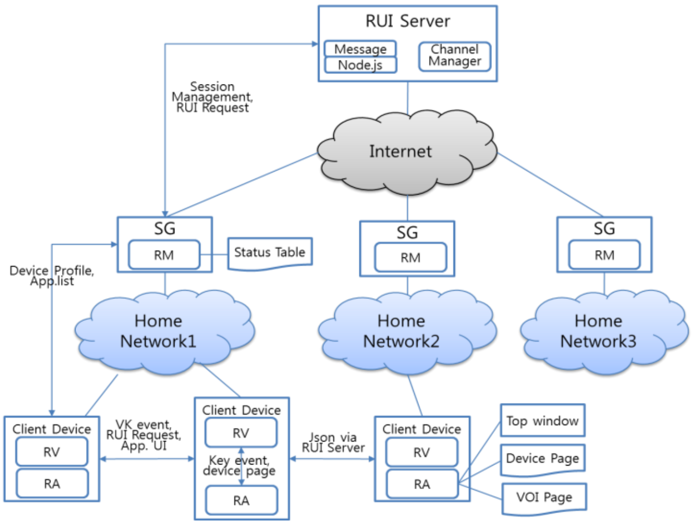


Fig. 1. The proposed RUI network configuration. There is a RUI server to interconnect all of home networked devices.

The RUI network is configured as Fig. 1. One SG (Service Gateway) and several fixed or mobile smart devices are internetworked in each home network. Smart devices control and share UIs with other devices using RUI framework. SGs are interconnected with each other through RUI server to support smart devices to control and share UIs with remote devices located at different home networks.

Service gateways manage devices and services of each home networks. Each SG also makes a channel in RUI server to allow remote devices to access local devices managed by them. The channel is set up with SG ID, login and password.

The smart devices can't send RUI messages directly to target devices because the most of them are networked with VPN (Virtual Private Network). Therefore, they require local SGs connected with them by same home network to forward their requests, formed as RUI messages, to remote devices. SGs also forward the requests to remote SGs connected with the target devices with the help of RUI server.

RUI server manages channels with ID, login and password as well as IP address for SGs, and forward the received RUI messages to SG designated with SG ID after verifying login and password included into RUI messages. For this, RUI server also support asynchronous HTTP based communication protocol for SGs to send and receive forwarded RUI messages asynchronously.

Below diagram describes the procedure of making a session and exchanging RUI messages among RUI devices through RUI server.

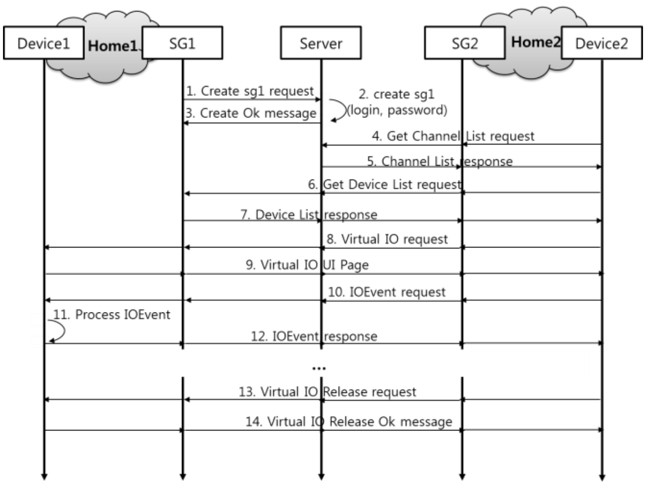


Fig. 2. The procedure of communication among RUI devices located at different home networks. RUI server manages channels of SGs to forward the input RUI messages to target devices.

B. *Components of the RUI framework*

Three kinds of RUI components are launched on the home networked devices such as SG and client devices. Their functions are described at Table I.

TABLE I
COMPONENTS OF THE PROPOSED RUI FRAMEWORK

Components	Function
RUI Manager	- manages the home networked devices and RUI services - provides local devices with method to communicate with devices outside home
RUI Agent	- manages the UIs of launched applications and virtual IO page - collaborates with other devices for sharing of UI and IO functions
RUI Viewer	- displays application UI and virtual IO UI - handles the user events

RM (RUI Manager) is the only component which runs on each service gateways and RA (RUI Agent) and RV (RUI Viewer) can run on every smart device.

The RM scans the RUI devices using the SSDP (Service Discovery Protocol) of UPnP. Whenever a RUI device turns on, The RA also find the RM using SSDP. If two devices are connected, then the RM collects device profile from the RUI device. The device profile includes device name, service list, address and device mode, and it is stored to RUI Status Table. The RM monitors the status of RUI devices. Client devices get the global information for RUI services such as RUI application list, RUI devices, from the RM. The status of client devices including current running RUI application and connection mode is stored to RUI Status Table together with device profile s. The RM also supports service session management among client devices. If a client device is gone, then the RM notifies it to another client device bound to disappeared client device.

The RV is implemented by extension of the WebKit to render HTML5 based UIs, and it handles user events invoked locally or remotely. The user events are transmitted to the RV's event queue by the RA whenever users input events with local input device or remote virtual input devices. The RV is launched automatically to render initial RUI Page by the RA.

The RA plays the most important role of RUI framework to share UIs for remote control of devices and applications among smart devices. The RA manages Top Window, Device Page, Virtual IO Page, RUI applications and local repository and so on.

The Top Window is displayed as an overlay window on the screen for interaction between users and RUI components. Users can request RUI operations of the RA by long touch on the top window for about 3 seconds. The RA shows the functions such as virtual IO on the Top Window, and then users select one of them to process.

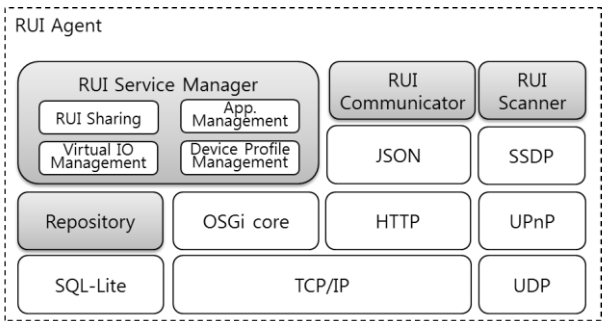


Fig. 3. The protocol stack of the RUI Agent.

The software elements of RUI Framework except the RV interoperate with each other using HTTP based messages. The RA provides the software elements with RUI Communicator APIs based on JSON message system. On the contrary, The RV is tightly coupled with the RA on every client devices, and they interoperate with each other using local procedure calls to invoke user's input events and to render application's or RUI initial UI page.

Virtual IO Page is also described as an HTML5 document including the key map of physical controllers such as remocon, mouse and keyboard provided locally. Virtual IO Page is transmitted to other Remote Agents for virtual IO mode. The Remote Agent shows the received Virtual IO Page to users by the RV to control remote devices using the similar user interface of physical controller.

The Device Page is changed according to current mode of client's device. When the RUI framework is launched, the page is set with the RUI Initial Page. If the device is bound to other device as virtual IO mode, then the page is set with the Virtual IO Page. Lastly, the page can be set with UIs of RUI applications launched locally or remotely. If the RUI applications are running on a remote client, then the UI to be set is moved to local device from the remote client.

The RA installs RUI applications to the repository of client devices, and manages their life-cycles. It also request remote RAs to launch RUI Applications installed on the remote devices. The UIs of RUI Applications are able to be migrated into other devices for remote control. The UIs and Virtual IO Pages are distributed to remote RUI Agents using OSGI's core APIs. In this paper, the UIs and Virtual IO Pages are handled as sub-apps included in a service bundle.

C. Collaboration Model of RUI Application

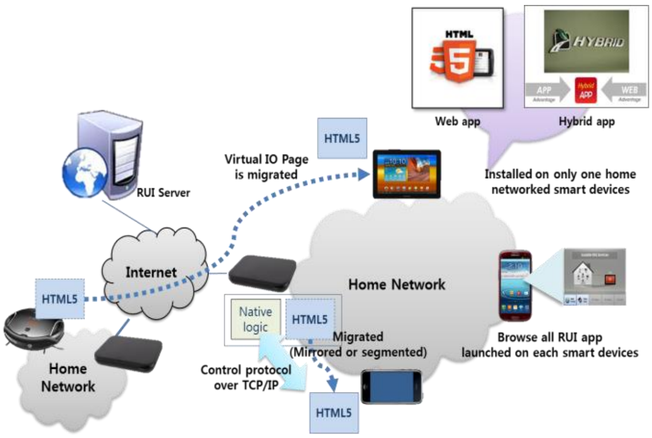


Fig. 4. The concept diagram of the proposed collaboration model. HTML5 based UI is composed of serveral parts to be shared by serveral devices.

RUI based services are installed on one of inter-connected smart devices by users. Users can browse the service list regardless of local service or remote service by RUI service browser. When users select a service, the selected service will be launched on the device which it is installed on. Users can control the remote service by the proposed RUI protocol based on migratable UI as Figure 5.

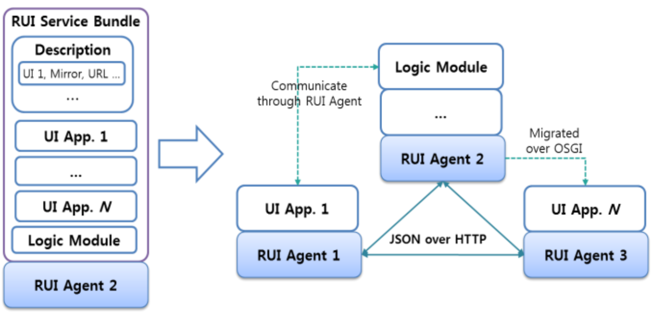


Fig. 5. The collabroation model of RUI applications. Migrated UI segments will communicate to the logic installed in local device through RA.

The Sub-description of each UI segments includes attributes such as segment ID, sharing mode, URL and input event model etc. Three kinds of the UI sharing modes are provided as follows.

1) Mirror

The UI of the original application which runs on the remote device is duplicated, and the UIs are transmitted to multiple devices. If an input event is invoked in the original UI, then all the duplicated UIs also receive the invoked event at the same time.

2) Migration

The original UI of local device is moved to selected devices. This mode is needed to display the local UI on the bigger screen. The local UI is automatically changed into virtual IO mode to control the migrated UI with local device.

3) Segmentation

The parts of Remote UIs are pulled and rendered on the display of local device. The UIs may be displayed on multiple devices according to the requests of several users at the same time.

As described in Fig. 2, Virtual IO page can be transmitted to globally networked devices for remote control through RUI server. The RUI messages of Virtual IO Page and invoked user events are routed to remote devices through local SG, RUI server and remote SG. Because of the problem of synchronization, the UI of application can't be shared between two devices located at different home until now.

The migrated UIs and logic communicated to each other with RUI messages which have the format as Fig. 6.

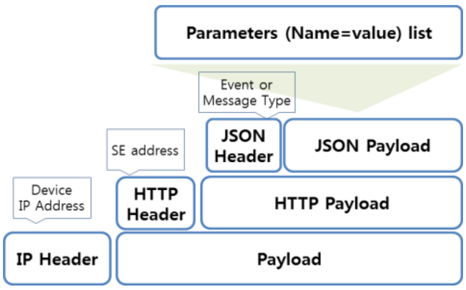


Fig. 6. The Structure of RUI Message. SE address contains ID to distinguish which target is local devices or remote devices and target software element.

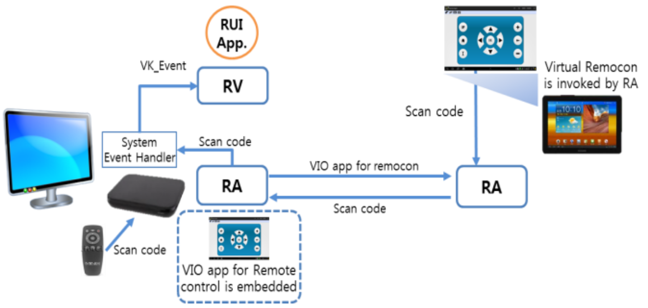
The address of RUI message consists of SG ID, device UUID, software element ID and segment ID to distinguish software elements. The kinds of software elements are classified into RUI applications (UI segments, logic apps) and RUI components (RM, RAs).

The IP address of RUI message is decided by the related information stored to the RUI Status Table such as the composition of device ID, application ID and UI segment ID (application ID is allocated per RUI service and included in service descriptions).

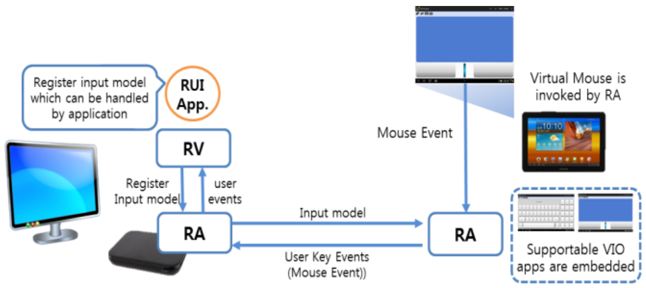
A RA figures out the SG ID is local or not before transmission of RUI messages. If SG ID is for local SG, then the RA transmits RUI messages to target elements directly. Otherwise, the messages are redirected to target elements of globally networked devices via RUI server. First, RA tosses RUI messages to local RM to forward those messages to target elements. Then, Local RM transmits RUI messages to RUI server to be verified and forwarded to target RM. lastly, the remote RM transmits the received messages to target device using IP address mapped to device ID contains in the messages.

D. Virtualized Input Devices

The proposed RUI framework provides two virtual IO modes for users to utilize smart devices as remote controllers as shown in Figure 7.



(a) Device based virtual IO mode



(b) Application based virtual IO mode

Fig. 7. Virtual IO action model. Virtaul IO Page is pulled to local device, so users can control the remote device as local device.

The first mode is the device virtual IO mode which user device plays the role as same as physical controller of other smart devices. Each RA manages Virtual IO Page which describes control UI of local device's physical controller such as remocon or control panels. The Virtual IO Page is described as HTML5 based application which can be rendered by the RVs of other devices. The Virtual IO Page is transmitted to other devices and launched by RVs of the devices, when users want to control remote devices by virtual IO mode.

User inputs are transmitted to remote RA as remocon control codes, and the codes will be consumed by system event handler. The system handler forwards codes to user event handler after converting them into key events. This procedure is also processed when user press a button of physical remocon. If any smart appliances, such as refrigerator, boiler and washing machine as well as TV, can be accessed from internet, then user can remotely control them using device based virtual IO mode at any home.

The second mode is the application virtual IO mode which user can select necessary type of virtual controller dynamically. RA manages embedded virtual IO emulators to be launched by only local RV, not by remote RVs. Virtual IO emulators are predefined in the repository of the RA according to the capabilities of local devices.

RUI applications should notify the type of input model for control their UI segments to RAs which launch the UI segments according to user's request, and RAs will provide users with selectable IO emulators among embedded emulators. If an event model contains keyboard and mouse, then the icon of keyboard and mouse is displayed in the virtual IO menu to be selected by users.

If a virtual mouse emulator is selected then user's inputs are transferred to remote RA through local RA as Mouse Events. Then the remote RA forwards the Mouse Events to RV, and RUI Apps (UI Segments) consume the Mouse Events generated by RV. This procedure is different with that of physical remocon.

III. Reference Implementation

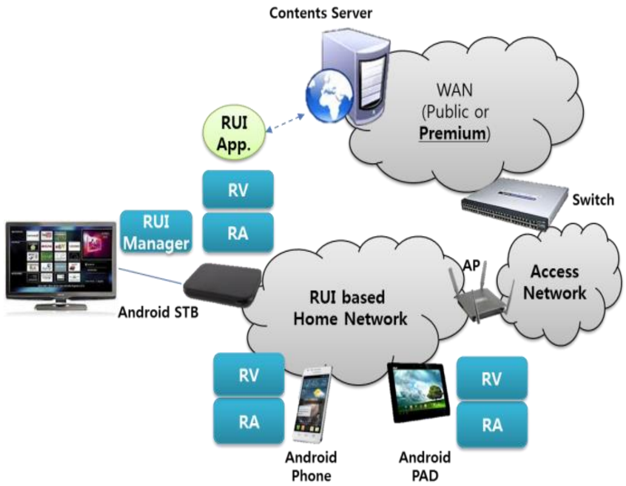


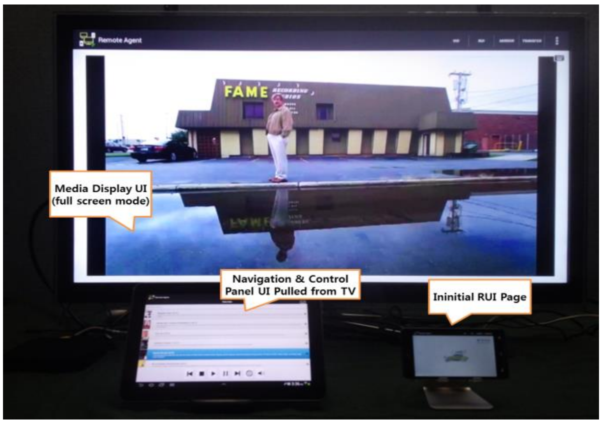
Fig. 8. Network configuration of a reference implementation. All devices are interconnected with one home network except contents servers.

A reference platform is implemented to show the functionalities of the proposed RUI framework together with an exemplary RUI application. The network configuration of the reference platform is shown as Figure 8 and Table II.

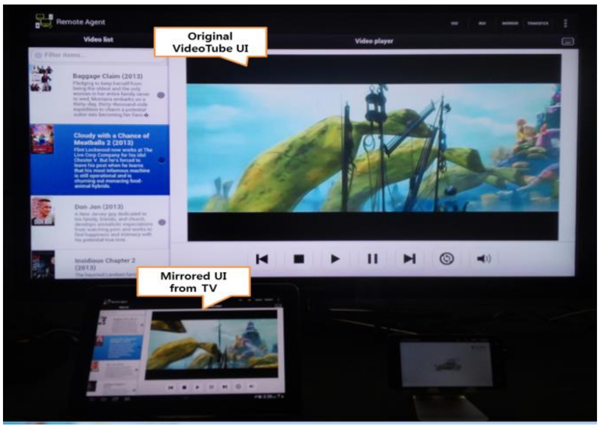
TABLE II
The Details of Device and Software Environment

Item	Details
Hardware	- Set-top box, smart phone, smart pad Android 2.x.x, dual core, RAM:2GB - Contents Server (PC), Windows 7, quad core: i-7, RAM: 4GB, HDD: 1T, 5400RPM
Networks	- AP (WiFi n/g, Ethernet 100Mbps) and switch (1Gbps)
Software	- VideoTube RUI application (VOD client) media player, contents guide, media control functionalities (UPnP AV renderer) - VideoTube server UPnP AV architecture Directory service, HTTP based streamer - HTML5 based web apps - handles the user events

Android based a set-top box; a smart phone and a smart pad are interconnected by an AP connected to a Giga-bit switch. A VOD server is connected directly to switch as an UPnP AV server. VOD client is installed the set-top box as an UPnP AV Renderer. The RM runs on the smart pad to manage the status of RUI framework. Some HTML5 games found on websites by the keyword of "HTML5 games" are installed on both of set-top box and smart pad. The smart phone is only used to control other devices as a virtual IO or remote UI sharing mode.



(a) Segmenting RUI mode



(b) Mirroring RUI mode

Fig. 9. A Exemplary RUI service (Segmenting & Mirroring).

VideoTube RUI service was implemented for remote UI sharing functionality among home-networked devices as Figure 9. VideoTube is composed of a contents server and a media player to provide users with a VOD-like service.

The UI of media player is able to be fragmented into Media Display UI, Control Panel UI and Contents Navigation UI. In the (a) of Figure 9, a user pulled the Contents Navigation UI together with Control Panel UI from TV. Only Media Play UI remains on the screen of TV with full screen mode automatically. There are 8 kinds of layout templates are provided for various status of RUI sharing for VideoTube.

The mirroring RUI mode is shown in the (b) of Figure 9. The UIs of VideoTube are duplicated to smart pad, and users can control the VideoTube by local smart pad or remote TV. The user input events are multicast to all of mirrored devices as well as TV which launches the VideoTube.

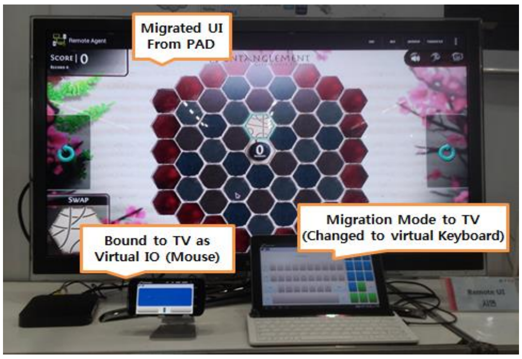


Fig. 10. An Exemplary Virtual IO service (Mouse & Keyboard)

Some HTML5 based web apps deployed on websites are used to verify our proposed virtual IO functionalities. Some of them are developed for PC, and the others are developed for mobile devices. Therefore, user's smart device should be virtualized into keyboard for PC version and virtualized into mouse for mobile device version according to user's selection. Fig. 10 shows an example of virtual IO service collaborated with TV and two smart devices.

An Entanglement game [15] is launched in PAD. When user requests the game migrate to TV, the UI of user's PAD is changed to the virtual Keyboard automatically. The phone is also bound to TV as a virtual mouse mode. Two users can play the game together simultaneously.

IV. CONCLUSION

The proposed RUI framework supports collaborative services using decomposable and sharable UIs among interconnected smart devices. The framework consumes less network bandwidths than the typical streaming based RUI protocols because the RUI framework uses HTML5 based UI and message driven interoperation between multiple devices, Moreover, users can use local devices as intuitive remote controllers of other devices using virtual IO emulators. Those functionalities can be provided to devices interconnected with different home networks through the RUI server using SG channels.

TABLE III
THE COMPARISON OF RUI PROTOCOLS

Function	Proposed	MIRACAST	Airplay	MOVL UI
Bandwidth	**Low**	High	High	Low
Mirroring	**OK**	OK	OK	NO
Collaboration	**OK**	NO	OK	OK
Virtual IO	**OK**	NO	NO	NO
Device Paring	**Easy**	Easy	Easy	Difficult
Platform Independent	**OK**	OK	NO	OK

Table Ⅲ shows that the proposed RUI framework is better than other RUI standards for various RUI functionalities.

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Bong-Jin Oh received B.S. and M.S. degrees in computer science from Pusan National University, Busan, Korea in 1993 and 1995 respectively, and the Ph.D. degree from Chungnam National University, Daejeon, Korea in February 2012. Since 1995, he has been with the Electronics and Telecommunications Research Institute (ETRI), where he develops home network middleware and data broadcasting middleware. His research interests are home network middleware, data broadcasting middleware, IPTV, pervasive computing, and big data analytics.

Jongyoul Park received the B.S. degree in computer engineering from Chungnam National University, Korea, in 1996, the M.S. and Ph.D. degrees in information and communication engineering from the Gwangju Institute of Science and Technology (GIST), Korea, in 1999 and 2004, respectively. From 2001 to 2002, he was a visiting researcher at the school of computing, University of Utah. Since 2004, he has been a Research Staff and Director of Analytics SW Research Section of Electronics and Telecommunications Research Institute (ETRI), Korea. His research interest includes IP broadcasting, software middleware, mobile code, distributed computing, big data and analytics platform.

Enhancing Routing Energy Efficiency of Wireless Sensor Networks

Noor Zaman*, Tung Jang Low**, Turki Alghamdi***

*,** Department of Computer Science & Information Science, Universiti Tecknologi PETRONAS, Malaysia, ***College of Computer and Information System, Umm Al-Qura University, Saudi Arabia

Noorzaman650@hotmail.com, lowtanjung@petronas.com.my, taghamdi@uqu.edu.sa

Abstract—Nowadays Wireless Sensor Networks WSNs are playing a vital role in several application areas ranging health to battle field. Wireless sensor networks are easy to deploy due to its unique characteristics of size and self-organizing networks. Wireless sensor nodes contain small unchangeable and not chargeable batteries. It is a resource constraint type network. Routing in WSN is most expensive task as it utilizes more power resources. This paper is intended to introduce energy efficient routing protocol, known as Position Responsive Routing Protocol (PRRP) to enhance energy efficiency of WSN. Position responsive routing protocol differs in several ways than other existing routing techniques. Position response routing protocol approach allows fair distribution of gateway\cluster head selection, maximum possible distance minimization among nodes and gateways\cluster heads to utilize less energy. Position responsive routing protocol shows significant improvement of 45% in energy efficiency of wireless sensor network life time as a whole by increasing battery life of individual nodes. Furthermore PRRP shows drastic increases for data throughput and provide better solution to routing energy hole due to it fair distributed approach of gateway selection. This work is the extension of Energy efficient routing protocol for wireless sensor network published in IEEE ICACT 2014.

***Keywords*— CELRP, Energy Efficient, WSN, PRRP position responsive routing protocol, Routing protocol,**

I. Introduction

WSN is a popular and have capability to high penetrate with several applications areas. It consists of small nodes having limited sensing, computation, and wireless communications capabilities [1-2]. Sensor nodes normally sensed data and forward sensed data to the base station such as temperature, sound, vibration, pressure, motion or pollutants [3].

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Dr. Noor Zaman is associated with King Faisal University, Saudi Arabia, (phone: +966-566117159; e-mail: nzaman@kfu.edu.sa).

Dr. Tung Jung Low, is associated with University Teknoloigi Petronas, Malaysia, (e-mail: lowtanjung@petronas.com.my)

Dr. Turki Alghamdi is associated with Umm Al Qura University, Saudi Arabia. (e-mail: taghamdi@uqu.edu.sa).

Sensor nodes normally sensed data and forward sensed data to the base station such as temperature, sound, vibration, pressure, motion or pollutants [3]. Sensor nodes are resource constraint type of network and contain very tiny size of irreplaceable and not chargeable batteries. Network life is the highly concern, energy become reason to dyes of nodes and network partially\ fully stop working [4-6]. Energy consumed more during path finding and data transmission operations terms as routing. Routing is the most challenging issue and direct concern to energy in WSN comparable with ad hoc and cellular network [7-8]. Clustering technique for routing in WSN is considered most suited based on its characteristics such as energy-efficient, scalable, lower latency, etc. In clustering, WSN network is divided into sub networks\clusters and each cluster has cluster head which is responsible to collect the sensed data from his cluster and forward it to the base station [9]. Cluster heads consumed more energy due to collecting and forwarding data from cluster while remaining nodes in the clusters still have more energy of 90% of their initial energy [10-12]. This situation normally happened due to unbalanced energy assumption which causes more drain of energy from nodes far from cluster heads [13] in random fashion from sensor nodes. To address this issue, several energy efficient routing algorithms and protocols have been propose recently, including cluster based protocols [14-19], power-aware routing [20-22] and multi-level transmission radii routing [23]. The minimum energy routing problem has been addressed in [24]. If sensor nodes consume energy more equitably, they continue to provide connectivity for longer and the network lifetime increases. [25-36].

As sensor networks have specific requirements on energy saving, data-oriented communication, and inter-connection between non-IP and IP, therefore sensor network-dedicated routing protocols may be required, for Energy efficient routing scheme.

II. Problem Statement

Sensor network has primary role to sense and forward data to destination or base station BS, resulting of any physical event occurrence. Routing plays a key role to identify path and transfer data in energy constraint sensor network. Initially routs defined by the nodes then nodes become able to send or receive the data by using those routing paths. In case if sensed data is available to some segments of network but network not able to transfer it to the destination due to the energy deplete of sensor nodes for some segments.

III. RELATED WORK

Several routing protocols have been developed recently to address the energy efficiency issue. WSNs routing protocols normally specified in following types.

1. Flat routing Protocols
2. Hierarchal routing Protocols
3. Location based routing Protocols

Hierarchal routing protocols work in cluster formation and considered to be more energy efficient due to their unique characteristics. Recently proposed Cluster based Energy Efficient Location Routing Protocol (CELRP), also belongs to Hierarchal type. In CELRP sensor nodes are normally distributed into clusters and divided into different quadrants. Each quadrant contains two clustering and sensor nodes that transmit data with two hops data transmission [37]. CH is selected based on the node with maximum residual energy and minimum distance to the base station in each cluster. While the CH which has the highest energy residual is chosen as the CH Leader between all the other CHs. CELRP applies Greedy algorithm among cluster heads and forward data to the sink. The collection works as nodes sends data to CH and then CH forward their data to the sink through CH leader by minimizing number of hops. CELRP assumed that the Base Station has all the information including the sensor nodes, the residual energy and the distance of node from sink. Sink is place far from the sensor node area. The CELRP based on three phases, in first phase it works for the formation of clusters, network divided into four quadrants and then it forms clusters. In second phase it selects CH and CH leader on the basis of its energy and finally with third phase it transfer data to the sink. CELRP has main limitations like its number of children nodes is high in the clusters and secondly its CHleader choosing mechanism works on the basis of energy level, in most of the cases CHleader is not the closest to CH, hence it causes more energy drain because of longer distance. At the same time it uses Greedy approach for data transmission which also causes loss of energy efficiency.

Hence it is highly needed to design an energy efficient routing protocol with assumptions closer to the real, we are position responsive routing protocol (PRRP) WSN routing protocol which is more energy efficient than the existing protocols.

IV. SYSTEM MODEL

Our assumptions for sensor network are such that, sensor nodes are randomly distributed over an area of 90 x 90 meters with following network properties.

1. Network is static and nodes are distributed in random format, while area is divided in equal square grid format.
2. There is exists only one base station, which is deployed in the center of the area.
3. The energy of sensor nodes cannot be recharged.
4. Sensor nodes are location aware.
5. The radio power can be controlled, i.e., a node can vary its transmission power.

Above all assumption are on wide scope, assumption no. 5, is becoming the cause of energy saving, as nodes will be aware about their location and sink too, hence the amount of energy which normally network always use to find out the initial location will be saved.

A. Network Model

The entire simulation tests were conducted by using a very well-known simulator by the research community NS2, by applying different topologies and approaches. The few of those topologies are shown below. In the entire topologies sensor nodes were distributed within an area of 80*80 meters and then tested their routing capabilities in two ways, initially it was tested with a normal distribution, while in second phase it was tested through position responsive (PR) Algorithm, in which each node was aware about its neighbors' location. The second approach for the routing was tested more excellent in terms of its power saving or in terms of nodes life optimization, which we discussed with coming section of results with the help of simulation graph fig. 1. The following is one of the screen shot scenario for distributed sensor nodes in Fig. 1

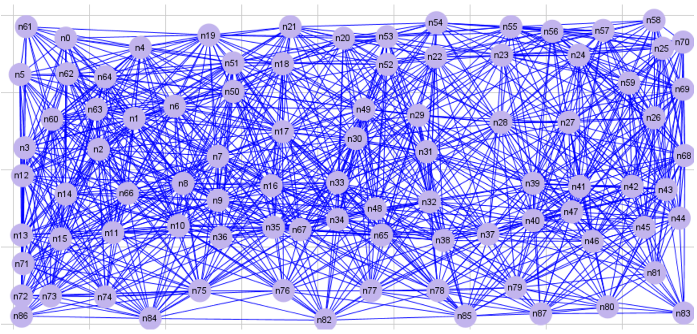

Fig. 1 Sensor nodes distributed with different topology

B. Energy Model

The power control model, used in this research in which the energy is consumed, during the transmission will depend on the transmission distance [38]. The energy consumed by a node (E_{Tx}) during transmission of k bits to another node at a distance of d meters, and the energy consumed (E_{Rx}) to receive k bits are calculated as:

$$E_{Tx} = kE_{elec} + k\,E_{amp}d^2 \qquad (A)$$

$$E_{Rx} = kE_{elec} \qquad (B)$$

where,

E_{elec}: represents the electronics energy

E_{amp}: represents the amplifier energy

E_{elec} represents the electronics energy and is determined by several factors such as digital coding, modulation, filtering, and spreading of the signal. On the other hand, E_{amp} represents the amplifier energy. In our experiments, it is assumed that E_{elec} =50 nJ/bit and E_{amp} =100 pJ/bit/m^2, which are the same values used in [37]. The initial energy stored in each node is 2 J. Since it is quite interesting to compare different protocols in terms of the energy consumed in transmission and receiving states, we ignore the energy consumed in sensing the environment as it will be same for the evaluation of all protocols. Furthermore, the node will be considered a dead node, and will not participate in the coming round if its energy becomes less than a threshold value ($E_{threshold}$).

For example, a node, in the worst case, will be a non-leaf node and will have eight (08) children in the coming round. For a single transmission period, it will receive a maximum of eight (8) data packets and transmit one data packet. Then, the minimum energy for this node to be able to participate in the coming round $E_{thresholdmin}$ can be computed as follows:

$$E_{thresholdmin} = kE_{elec} + kEampd^2 + 8kE_{elec} \quad (C)$$

Assuming that the size of data packets is 100 bytes and the maximum distance is √2 x 5 m, and using the values of E_{elec}, E_{amp} as in 3.3, $E_{thresholdmin}$ for a single data transmission period will be (376 μJ). Taking into account the energy needed for selecting gateway, building the tree and TDMA schedule, it is empirically found from extensive simulation results that (400 μJ) is a good estimate for $E_{thresholdmin}$ for a single data transmission period. A reasonable good estimate means that if the node has a residual energy equal to this $E_{thresholdmin}$, this energy will be sufficient for the node to participate for a round with a single data transmission period and the node will stay alive until the end of the one period in the round.

Now, for five and ten data transmission periods, $E_{thresholdmin}$ will approximately be 2000 μJ and 4000 μJ, respectively. This assumption is a pessimistic one as it simply multiplies the energy needed by one cycle of one data transmission period by 5 or 10, respectively. Of course, in reality actually energy used will be less as the first three phases of the process are only done once. On the other hand, it is assumed that the isolated nodes are dead nodes. Isolated nodes are the nodes that do not receive a broadcast message to join the tree.

C. Energy Analysis

Concerning energy efficiency of PRRP, This section presents an analysis of energy utilization in terms of energy consumed by cluster head nodes and leaf nodes. Consider a wireless sensor network comprising N wireless sensor nodes that are uniformly distributed within a grid of size m × m; within each cell one of node acts as the cluster head (CH), so the number of cluster heads will be same as the number of cells, i.e. m^2.

We shall use the following symbols to denote quantities mentioned against each:

k : Number of leaf nodes in a cell; i.e. k =$\frac{N}{m^2} - 1$; (not counting the CH),

E_t *:* Energy to transmit one sample,

E_r *:* Energy to receive one sample,

E_{in} : Initial energy provided to each node at the time of deployment,

E_{th} : Energy Threshold below which a node cannot act as a cluster head

E_{ln} : Energy consumed by Leaf node

P_s *:* Power consumed while a node is asleep,

T_t : Time to transmit one sample,

T_s : Sampling interval,

Energy Consumed by leaf nodes

For leaf nodes, there are two modes of energy consumption namely: energy consumed in sleep state and energy consumed during transmission. During each sampling interval T_s, a leaf node spends T_t time for transmission and the remaining $T_s - T_t$ time in sleep mode. Thus energy consumed by a leaf node, E_{ln} can be calculated as|:

$$E_{ln} = E_t + (T_s - T_t)P_s \qquad (A)$$

Energy Consumed by cluster heads

As cluster head spends its life in three modes, namely: receiving samples from leaf nodes, transmitting its data and sleep mode. Since, the energy consumed to receive a sample is E_r and there are k leaf nodes in each cell; thus, total energy consumed by CH in receiving k samples is $k\,E_r$, while energy consumed by CH during transmission is E_t. During each sampling interval, a CH spends $k\,T_t$ time for receiving samples, T_t time for transmission and remaining $T_s-(k+1)T_t$ time in sleep mode; thus energy consumed in sleep mode is $P_s \times (T_s-(k+1)T_t)$. The total energy consumed by a CH during one sampling interval, E_{ch} is given by:

$$E_{ch} = E_t + k\,E_r + (T_s-(k+1)T_t)P_s \qquad \text{(B)}$$

Next, we calculate life of a CH in terms of number of sampling intervals, N_s while its remaining energy is more than the threshold E_{th}. Thus,

Total life of a CH, $$N_s = \frac{E_{in} - E_{th}}{E_t + k\,E_r + (T_s-(k+1)T_t)P_s} \qquad \text{(C)}$$

Life of a leaf node

Once a CH dies, a new round of cluster head selection is initiated. In the following paragraphs, we show that leaf nodes still have enough energy left to participate as cluster heads in future rounds.

The initial round leading to exhaustion of a CH consists of N_s sampling intervals as shown above. Therefore, energy consumed by a leaf node during the first round, E_{ln1}, is given by $N_s \times E_{ln}$; i.e.,

$$E_{ln1} = N_s \times E_{ln} \qquad \text{(D)}$$

Using Eqs A and C, Eq D becomes:

$$E_{ln1} = \frac{E_{in} - E_{th}}{E_t + k\,E_r + (T_s-(k+1)T_t)P_s} * (E_t + (T_s - T_t)P_s)$$

Assume that $P_s \cong 0$ and divide equation D with E_t we will get

$$E_{ln1} \cong \frac{E_t(E_{in} - E_{th})}{1 + k\,E_r/\,E_t}$$

Typically, energy consumed during transmission of a number of bits is about four times as much as energy consumed for receiving the same number of bits[39], that is to say that $E_t = 4\,E_r$.

So $$E_{ln1} \cong \frac{E_{in} - E_{th}}{1 + k\,/4} \qquad \text{(E)}$$

It is obvious from Equation (E) that at the end of first round, for a sufficiently large cluster size, leaf nodes consume only a fraction of their energy reserve. Thus, the network will last for many rounds after the death of first cluster head.

V. RESULTS & DISCUSSION

In this section, it is attempted to compare our proposed PRRP protocol with CELRP. In CELRP sensor nodes are normally distributed into clusters and divided into different quadrants. Each quadrant contains two clustering and sensor nodes that transmit data with two hops data transmission [36]. CH is selected based on the node with maximum residual energy and minimum distance to the base station in each cluster. While the CH which has the highest energy residual is chosen as the CH Leader between all the other CHs. CELRP applies Greedy algorithm among cluster heads and forward data to the sink. The collection works as nodes sends data to CH and then CH forward their data to the sink through CH leader by minimizing number of hops. CELRP assumed that the Base Station has all the information including the sensor nodes, the residual energy and the distance of node from sink. Sink is place far from the sensor node area.

CELRP have main limitations such as the number of children nodes is higher in the clusters like LEACH and secondly its CHleader choosing mechanism works on the basis of energy level, in most of the cases CHleader is not the closest to CHleader, hence it causes more energy drain due to longer distance. CELRP consider the placement of sink far from the sensing area and at the same time it uses Greedy approach for data transmission which both also caused loss of energy efficiency. Hence above stated limitations causes major sources of energy drain. PRRP becomes more energy efficient by using different techniques for stated limitations besides of other considerations. This section is aimed to discuss the performance evaluation of PRRP and CELRP and to compare them on the basis of number of live nodes vs time, total consumed energy and network throughput one by one and collectively for different data transmission periods.

A: Comparison Analysis on the basis of Live Nodes

This section describes comparison analysis of results for live nodes among CELRP and CELRP for different data transmission periods individually and collectively. Fig. 01 shows a comparison between PRRP and CELRP in terms of number of live nodes initially for single period of transmission. Here, our network is tested with different periods and rounds of data transmission such as 1,5 and 10. After discussing all one by one, all of them finally and collectively shows for a better understanding of the difference between CELRP and PRRP. The following Fig. 01 presents the comparison for the single round only.

Our observation shows significant results of PRRP over CELRP for different periods and rounds. Initially its result shows little differences but finally through the increase in the number of the periods, it brings more significant differences as shown in Fig. 02. PRRP shows a more time network operational with single period, which is almost up to 140 seconds, yet CELRP goes up to 120 seconds only.

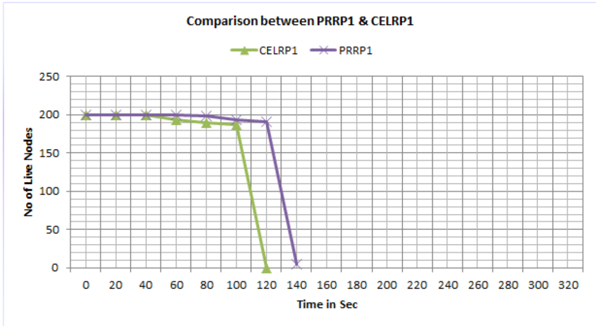

Fig. 02 Number of Live Nodes vs. Time, (PRRP & CELRP with one Period)

Furthermore, we observe the same difference in a notable improvement when testing our network for the 5 periods as shown in Fig. 03 below. The results then show that PRRP goes up 300 seconds of time, while CELRP reaches up to 200 seconds. This difference will increase whenever we test the network for the different and more number of rounds. This positive difference comes due to the efficient mechanism of the gateways selection and functioning in PRRP. The area of operation of the neighbors of the PRRP is always close to its gateway for saving its energy level as shown in several different cases of different rounds of data transmissions and at the same time CH have less distance from the sink as it is placed in the center.

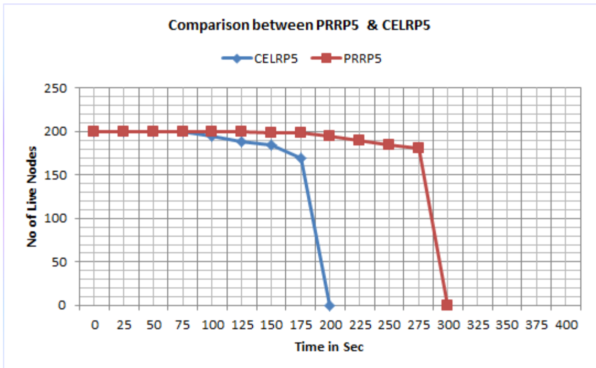

Fig. 03 Number of Live Nodes vs. Time, (PRRP & CELRP with Five Periods)

In the third test, we compare CELRP and PRRP for 10 numbers of periods as shown in Fig. 03. It shows that PRRP has a more significant performance than CELRP for all scenarios. For example, considering the scenario of 10 data transmission periods, the network life is significant improved for PRRP with an excellent improvement in sensor network lifetime, which is almost 400 seconds, while for LEACH it is about 300 seconds. The improvement in PRRP is because of the efficient use of the energy for all nodes is up to its last limit and also has an opportunity to participate all nodes in the network without having any network isolated part with it. Secondly, the energy enhancement in PRRP is because of minimizeed energy consumption with each node by decreasing the distance between the gateway and the non-leaf nodes and between the sink at the same time.

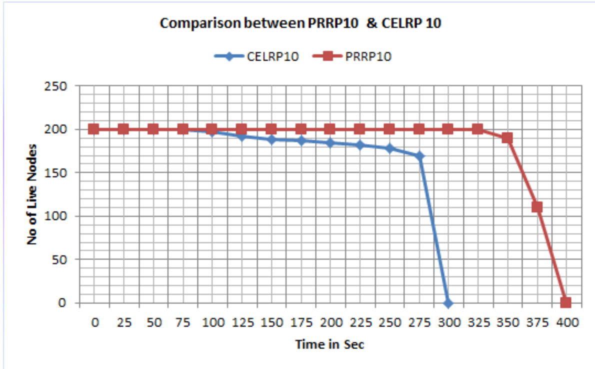

Fig. 04 Number of Live Nodes vs. Time, (PRRP & CELRP with Ten Period)

By comparing the energy consumed by a node in CELRP and PRRP, a difference in status of the nodes will be found in CELRP and PRRP. It should be considered that there are three different types of the nodes in PRRP; while in CELRP it is only two types of nodes such as normal node or non-head node and Cluster head or head node, while the CH leader is to be chosen from one of the CH on the basis of its energy level . In PRRP nodes on the other hand has three following different types such as non-leaf node, leaf node and gateway nodes. Energy can be compared on the basis of energy consumed through all nodes during transmitting, receiving and idle-listening state.

When we compare PRRP with CELRP for different periods of data transmission, PRRP always shows an excellent improvement with energy saving of the network, as collectively shown in Fig. 05. Simulation results shows a significant result with an increase in number of the rounds of PRRP, as PRRP uses a mechanism in which if the same node has some residual energy level, each node can be a gateway until the end. This approach enables PRRP to save more energy and use all nodes energy up to its last maximum limit. The difference can be easily monitored in Fig. 05 presenting the collective results of different data transmission rounds.

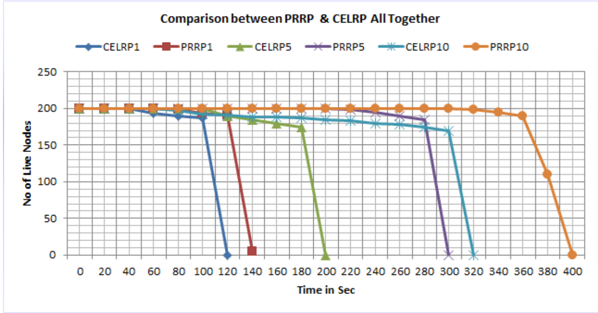

Fig. 05 Number of Live Nodes vs. Time, (PRRP & CELRP Collectively)

B: Comparison Analysis on the basis of Total Energy Consumed

As mentioned in earlier sections, in tree building phase in PRRP, the nodes can transmit signals with minimum energy level. Whilst, the parent can select node which is closer to the node on very short distance which saves its energy level. In comparison with CELRP, parent of node can be any node, CELRP do not consider the distance among nodes and CHs. If we compare the energy consumption by leaf node in PRRP and normal node in CELRP, it can be noted that both types of nodes will not lose energy due to receiving data or idle listening. As a TDMA transmission scheme is implemented, they will not lose any energy and node will be only *ON* at its schedule time only.

The transmission distance is very short in PRRP, as the parent node is near leaf node. While in CELRP the main part of the energy is consumed during the data transmission phase in particular when the normal node is at a distance from the cluster head and mostly CH leader is on longer distance from the CH. The second main reason for the energy loss in CELRP is the sink is place on long distance hence overheads becomes more for nodes which are far from the sink. Thus, there is a chance that the CH leader and cluster head itself might be so far from the normal nodes and becomes the factor of energy loss during the data transmission phase. Furhermore, by comparing non-leaf node and the cluster head node of CELRP, it can be found that non-leaf node in PRRP is not losing its energy due to the idle listing as it schedules to receive and transmit data at the specific time slots only. It is also found that in CELRP cluster head should remain ON to transmit its data to the sink and cluster head uses CSMA technique. Therefore, it loses the energy.

The number of the children is less related to any gateway in PRRP. It is due to the gateway, compared to the head in CELRP, has less number of children, thus making it consume less energy in receiving data. This also comes to be a factor for a deep tree building in which neighbor nodes remain closer to the gateway. In CELRP any cluster head, conversely, might have a more number of children nodes at different distances. This in CELRP also becomes the factor of energy decrease. For this, the total consumed energy in PRRP will be smaller in comparison to CELRP as shown in the following Fig. 06 for different data transmission periods.

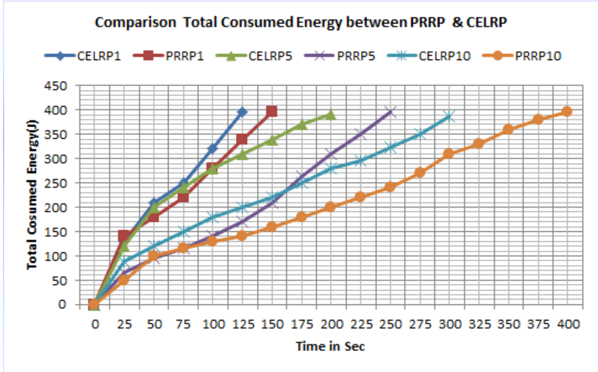

Fig. 06 Total Consumed energy vs. Time, (CELRP & PRRP)

As an illustration, if we compare to 10 data transmission periods at t=150 seconds, the total consumed energy is about 230 J in CELRP and about 140 J in PRRP. The consumed energy is dropped by a significant difference almost 100%. The overall energy consumed by the end of the network lifetime is efficient by both the protocols. However, the important concern is that which protocol can achieve a longer lifetime and higher throughput for the same initial energy level.

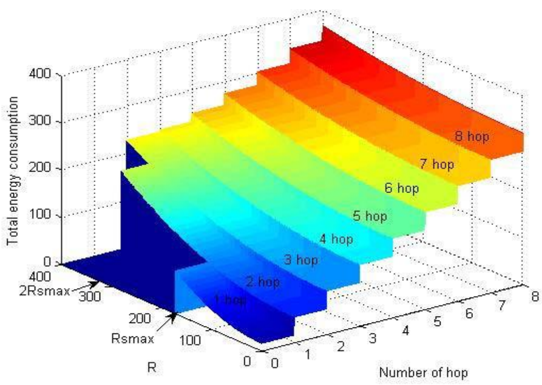

Fig. 07 Energy Consumptions over the number of hop.

Fig. 07 shows total energy consumption based on simulations for different hops, where the number of nodes were considered as of 200 with having energy level of 2 J for each and overall energy of 400 J. The author has shown one more aspect of the result that if the sink is placed far from the sensing field, in that case the number of hopes will increase from the node to the sink that increases the loss of energy as distance increases from the node to the sink. In PRRP, the sink is placed in the center of the sensing field to decrease the possible number of hops among nodes and the sink and at the same time to decrease the distance among the nodes and CHs.

C: Comparison Analysis on the basis Throughput

This sub section describes about network throughput which shows a substantial growth because of increase in overall network energy efficiency. In PRRP protocol, the main energy is saved during the data transmission phase with multiple data transmission periods by utilizing same build tree for multiple periods. The network survives longer because of less distance between nodes and gateways. The following Table 01 is showing the comparison between PRRP and CELRP protocols in term of the data packets delivery to the sink for different periods.

TABLE I

A comparison between PRRP and CELRP in terms of throughput

Periods	**PRRP**	**CELRP**	**Improvement with PRRP**
1 Data Transmission period	16733	5950	2.81 times
5 Data Transmission periods	54555	19985	2.72 times
10 Data Transmission periods	65305	35710	1.82 times

Overall, the performance of the PRRP is more significant than the one in CELRP. PRRP, in this case by enhancing the life of the sensor nodes and by utilizing each sensor nodes energy resource up to the maximum level, enhances the overall life time and energy efficiency of the network. As seen in Table 01, the comparison of PRRP and CELRP with different aspects is presented. The overall significant throughput is improved in PRRP through an application of it with multiple rounds of data transmission.

This improvement in fact is determined by two major factors. The first factor is related to the increase in the network lifetime in PRRP entirely that ensures more influx of data packet, directly giving an effect on the throughput of the network. The second one is about our assumption that any node in PRRP can become a gateway on the basis of different parameters, allowing the maximum nodes to be the gateways. However, gateway selection will be based on different parameters including energy efficiency, Position from the sink and number of neighboring nodes. Hence, the increase in number of gateways based on stated parameters in fact, comparable with CELRP, can decrease the depth of the tree, and also cause a good impact for the throughput of the network. This increase of data throughput is directly linked with overall energy efficiency of sensor network which can be achieved through our proposed PRRP.

VI. Conclusion

Wireless sensor network has important role and use, due to it's diversify approach and range of applications. WSN is the only most suitable and easy way of deployment in remote and hard areas. Routing is the main expensive operation for nodes energy consumption. This paper proposed new routing protocol known as Position Responsive Routing Protocol PRRP. Our proposed PRRP addresses energy efficiency, data throughput and routing hole under certain controlled conditions. Our simulation based research results showed a significant energy efficiency improvement of 35% to 45% in WSNs by increasing overall energy efficiency and life time. PRRP also shows a significant improvement of data throughput approximately 3 times to existence protocol CELRP. PRRP also addresses routing hole issue due to distribution approach of gateway selection and providing chance to maximum nodes for data transmission.

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Dr. Noor Zaman acquired his degree in Engineering in 1998, and Master's in Computer Science at the University of Agriculture at Faisalabad in 2000. His academic achievements further extended with a PhD in Information Technology at University Technology Malaysia (UTP). He has vast experience of 15 years in the field of teaching and research. He is currently working as a Faculty member at the College of Computer Science and Information Technology, King Faisal University, in Saudi Arabia.

He has contributed well in King Faisal University for achieving ABET Accreditation, by working as a member and Secretary for Accreditation and Quality cell for more than 07 years. He takes care of versatile operations including teaching, research activities, leading ERP projects, IT consultancy and IT management. He headed the department of IT, and administered the prometric center in the Institute of Business and Technology (BIZTEK), in Karachi Pakistan. He has worked as a consultant for Network and Server Management remotely in Apex Canada USA base Software house and call center.

Dr. Noor Zaman has authored several research papers, and edited five international reputed Computer Science area books, has many publications to his credit. He is an associate Editor, Regional Editor and reviewer for reputed international journals and conferences around the world. He has completed several research grants and currently involved with funded projects in different courtiers. His areas of interest include Wireless Sensor Network (WSN), Network, Cloud Computing, Big Data, Mobile Computing, Software Engineering, Unix, and Linux.

Dr. Low obtained his Bachelor of Engineering in Computer Technology from Teesside University, UK (1989), MSc IT from National University of Malaysia (2001), and his PhD in IT from Universiti Teknologi PETRONAS (UTP), Malaysia (2012). He is currently a Senior Lecturer in the Computer and Information Sciences Department of UTP.

He has been in the academic line for two decades already, mainly as lecturer cum researcher in various public and private institutes of higher learning. He teaches various engineering and ICT courses. His research interest includes wireless/mobile technology, embedded systems, wireless sensor networking, robotics, and Green IT. His current R&D include: bio-inspired energy efficient routing in WSN, sensors location optimization in green IT, and green by IT.

Turki Alghamdi graduated with B.Sc. degree (with honors) in computer science from the King Abdulaziz University, Jeddah, Saudi Arabia, in 2003. He was awarded M.Sc. degree in Distributed Systems and Networks from the University of Hertfordshire, Hatfield in 2006. In 2011 he received his Ph.D. degree in Computer Science from the University of Bradford, Bradford, United Kingdom. In 2003,

He joined the Department of Computer Science, University of Umm Al-Qura, as an Assistant Teacher. Since August 2011 he has been working for the Department of Computer Science as an Assistant Professor. He is a current administrator of recently established smart networks laboratory in the Computer Science Department. His current research interests include computer networks and Wireless Sensor Networks.

Optimization of Convenience Stores' Distribution System with Web Scraping and Google API Service

Thai Quang LE*, Davar PISHVA**

*International Management, Ritsumeikan Asia Pacific University, 1-1 Jumonjibaru, Beppu, Oita 874-8577 Japan

**Asia Pacific Studies, Ritsumeikan Asia Pacific University, 1-1 Jumonjibaru, Beppu, Oita 874-8577 Japan

quanle11@apu.ac.jp, dpishva@apu.ac.jp

***Abstract*—Vehicle Routing Problem (VRP) has never become an obsolete research theme in the field of operations research and supply chain management. Considering that significant number of researchers have already tried addressing VRPs with mathematical modeling and algorithmic approaches, this paper focuses on a practical implementation and employs programming techniques to cope with a particular business problem in convenience stores' distribution system. It optimizes goods distribution process of convenience stores business, which involves lorries delivering products from a warehouse to a network of several convenience stores in a single trip, collecting their garbage, passing by a gas station for re-fueling when needed, and returning back to the warehouse. A mathematical 'network flow model' is initially developed to examine the problem. Geographical data of convenience stores, their associated warehouses, garbage dumpsites and gas stations are subsequently retrieved through programming with the 'web scraping' technique. A prototype of web-based delivery navigation system that utilizes Google API service is then developed to solve the optimal convenience stores' networking problem. Furthermore, a more general perspective of the problem is illustrated with cluster-first-route-second heuristic algorithm and a mobile version of the prototype, which can serve as a real time navigation system for delivery truck drivers, is developed. Validity of obtained results is also examined by other known methods to justify optimality and fast performance of the approach.**

***Keyword*—Assignment, Google API Service, Maximal Covering, Modeling, Optimization, Supply Chain, Web Scraping.**

I. INTRODUCTION

It is fair to claim that profit maximization is the ultimate goal of any commercial firms. In a retailing business that comprises of thousands of stores or stations, even a small reduction in product cost can have a big impact on not only the business itself, but also to the nation's economy and social well-being as a whole. Over many decades, there have been many profound researches and proven practices suggesting various ways to make business more lucrative, but most of them focus on effective resources allocation and enhancing productivity, which then lead to production cost reduction. Moreover, in our push-button world where everything changes so quickly along with the high-pace development of technology, machines are gradually replacing the human role in several aspects, such as manufacturing procedures and business administration. Since potential effects of technology on business has not fully been exploited and more and more advanced and pragmatic technology is being invented by an increasing flow of capital investment in research and development (R&D) on a global scale, technology is believed to be one of the decisive keys in business competition today.

Furthermore, apart from profit maximization, more and more businesses are presently paying serious attention to corporate social responsibility (CSR), especially in environmental aspects. It has been a common sense to utilize the perspective of management in different aspects of doing business, and one argument for explaining this is that most business factors such as human capitals, production cost, market sales, etc. are measureable by human beings. However, recently technology has also enabled us to measure different types of environmental factors such as amount of carbon-dioxide emission and so on that are resulted from prolong business process. Data from such measurements force business managers to take environmental factors into consideration and lead the business with a more balance strategy between profit maximization and social responsibility. The challenge here is how to help business stay more lucrative, and at the same time remain friendly to the society and the environment. This is also the question that this paper would like to address, particularly in convenience store retailing business in Japan for which a systematic technological approach is suggested as an answer.

The remainder of the paper is organized as follows: Section 2 addresses delivery route optimizing perspective of convenience stores' distribution problem and some related previous work. Section 3 then delivers a practical solution to enhance the distribution process of a network of convenience stores, which includes network flow modeling, data collection by web-scraping technique, multi-objective route

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Thai Quang LE is a student at Ritsumeikan Asia Pacific University (APU) in the field of Business Administration focusing on Strategic Management and candidate for graduation.

Davar Pishva is a professor in ICT at Ritsumeikan Asia Pacific University (APU) Japan (corresponding author: +81-977-78-1000, fax: +81-977-78-1001, e-mail:dpishva@apu.ac.jp).

optimization with Google Map API and Evolutionary Algorithm in Excel, and an easy to follow Graphic User Interface (GUI) implementation on web-based mobile platform. Section 4 proceeds with detailed discussion and analysis of the research result. Sections 5 subsequently indicate some current limitations and potential future research and conclude the paper.

II. Literature Review

A. Convenience Store Business in Japan

Considering that Japanese people is famous for tireless dedication to working-life, convenience store turns out to be one of the key factors in timesaving for the majority of Japanese and lead to higher overall working productivity of the society. Due to the increasing dependency of Japanese society on convenience stores, growth in this retailing business is also a reflection of the Japanese present living standards [1]. Japan's convenience stores are well known for catering not only fruitful types of beverages, safe and healthy foods [2], but also to a plenty of in-store services, namely banking, printing, public utility payment (gas, telephone, electricity, etc.), ticket reservation for concerts or sport games and so on [3]. However, it is also claimed that not just the merchandising factor, but also time beneficial factor of convenience stores is important to the Japanese daily life [1]. To illustrate this, since most Japanese visit stores on foot [1], a high-density of roughly over five stores per kilometer, which can be much higher in metropolitan areas, enables anyone to access a store in less than 10 minutes on foot on average. Thus, it is reported that approximately sixty percent of customers visit the same store twice a week or more [2].

Convenience store business is one of the most profitable retailing businesses in Japan, covering 36% of the Japan Retail Food Market in the year 2012 [4-5]. With the increasing total of sales from roughly 8.7 trillion yen in the year 2011 to about 9.4 and 9.8 trillion yen in the year 2012 and 2013 respectively [4]. Regarding the number of stores, there are over 50,000 convenience stores located throughout 47 prefectures of Japan and the number of new establishments has been continuously increasing in recent years; from 43,373 stores in 2011 to 47,801 and 50,234 stores in 2012 and 2013 respectively. Most of the convenience stores are established in the metropolitan Kanto area, with more than 20,000 stores in the year 2013; and Okinawa has the lowest number of convenience stores, about 500 stores in 2013. Since most of the convenience stores learn the system from supermarket management experience, with their limitation of the small store sizes, convenience stores business is adapting many of state-of-art technologies, especially Electronic-Ordering-System (EOS) in collecting and analyzing Point-Of-Sales (POS) data in order to reduce effectively product delivery time from the wholesalers to each store [1, 6].

B. Convenience Store's Distribution Problem

The price charged for a similar item being sold in convenience store is usually more expensive (by about twenty percent) than in local supermarkets or mass merchandiser [7]. This overhead cost is considered as charges for the convenience values perceived by the customers. To illustrate, one can both purchase foods for dinners and pay the electric bill at a nearby convenience store, instead of passing by both a supermarket and a power utility office, which are not usually located in the same neighborhood. However, from the perspective of business managers, the overhead cost of convenience stores is mostly resulted from overnight operation and expensive merchandise distribution process.

In Japan, convenience stores maintain long business hours, usually beginning at seven in the morning and stay open until eleven at night. Because the average salary for a night-work shift (from six until midnight) is sometimes three times higher than the normal working hour, the convenient operating hours raise an additional cost for the business. Additionally, considering limited available land area in its vicinity, convenience store in Japan is usually defined as self-service store with average of 100 to 150 square meter floor space [1]. Because of such small size, convenience stores in Japan normally do not practice inventory, and a well-managed product distribution system is essential to the business development [1], which is called just-in-time delivery. Particularly, all of the products are distributed by trucks from a distribution center (warehouse) to all of the convenience stores on a regular basis. For example, 7-eleven convenience stores implement a combined distribution system by temperature zones by which rice, chilled products are being delivered three times per day, frozen and beverage products are being delivered three to seven times per week [2]. Because products have to be delivered to thousands of convenience store on an average 9 times per day (in the case of 7-eleven stores), the cost for hiring truck drivers and gas consumption rise up. And this expensive distribution process is believed to be the biggest overhead cost associated with the price.

Due to the limitation of floor space, convenience stores do not have the capacity to do inventory. Hence, in order to meet customer's needs, many of the convenience stores nowadays practice just-in-time distribution system, by which the products are only being delivered when needed. Therefore, on a daily basis, convenience retailers have to deliver goods by trucks from a distribution center to several stores, fill-up the gasoline when necessary, collect all the garbage, and dump the collected garbage at a designated dumpsite; and this distribution patterns have to be repeated many times per day. Throughout the years, convenience store business has found many ways to enhance the situation. For example, 7-eleven convenience stores pioneered the so-called temperature-independent distribution system by which mixed categories are combined before being loaded onto trucks so as to increase payload efficiency and tremendously decrease the replenishments of goods per day [2]. Nevertheless, in order to serve millions of people per day, still thousands of delivery vehicles, mainly trucks and mini vans, at least 3,799 of which belong to 7-eleven, are operating everyday and raising both economic and environmental concerns.

Hence, this research approaches the convenience stores' distribution problem as a vehicle routing optimization problem, which proposes a systematic way to minimize the total truck delivery time duration in networks of convenience stores, resulting in both financial and environmental savings.

C. Related Works

There have been a considerable number of research investigating vehicle routing problems (VRPs) in various fields, which can be considered as linear optimization with different operational objectives and constrains. In fact, many real-life VRPs comprise of huge number, sometimes hundreds or thousands, of nodes in a networks and it is very time-consuming as well as computationally expensive to obtain an exact optimality in the result. Because of such large scale and demand for multivariable constraints and decision parameters, most of the proposed solutions for VRP are based on heuristics, which can be classified as classical heuristics and meta-heuristic [8]. Just to cite, some of the classical heuristics are Clarke and Wright (1964) [9], Sweep, Petal, etc. Meta-heuristics include evolutionary algorithm [10], Taburoute [11], adaptive memory based tabu search [12], ant colony optimization [13], hybrid cooperating meta-heuristics [14] and so on.

There have also been several researches that implement or extend those algorithms in empirical businesses that practice routing optimization. A decision support system proposed by Lin, Choy, Ho, Lam, Pang, Chin (2014), which also considers level of service as a cost function and has a prototype on mobile-client for courier operation to minimize the total traveling distance [15], is one such example. Unlike convenience stores distribution problem, this problem of courier service involves the continuous alternation in the customer orders, making dynamic routing and flexible time windows as the main concentration of the research. Another recent VRP example is pickup and delivery of customers to the airport, which is examined by Tang, Yu, Li [16]. The research makes use of the CPLEX software to implement an improved label-correcting method to remove infeasible routes to speed up the route search process. A related work had also been carried out by Li, Chen, Sivakumar and Wu [17], which involves optimization of travel time for inventory routing in petroleum business. Due to the nature of the business, new constrains such as hours-of-service regulations of the industry, etc. were considered. Waste collection problem is another type of VRP concentrating on balancing the workload over time by optimizing the decision on container selection and routing, obtaining a cost savings of up to 40% [18]. Due to the uncertainties in traffic congestion and the importance of time management, several researchers have also incorporated time windows as constrains in building the model of the VRP. For example, a research done by Zarandi, Hemmati, Davari, and Turksen (2013) on the location-routing problem with time windows under uncertainty inspects the fuzzy attributes of demands of customers and travel time [19]. Tas, Jabali, Woensel (2014) also introduced a solution procedure to resolve the vehicle routing problem with flexible time windows, in which the customers can be flexibly served before or after a preset tolerable time frame in order to save operational cost [20]. In 2010, in order to tackle with driving hours regulations, a research on departure time optimization for VRP was also proposed by Kok, Hans, and Schutten (2011), which claim to reduce 15% of duty time of truck drivers with the newly introduced algorithm [21]. Regarding convenience store business, Bhusiri, Qureshi, and Taniguchi (2013) proposed a perspective of convenience stores' distribution as a "VRP with soft time windows and simultaneous pickups and deliveries", which focuses on using branch-and-price approach and evolutionary algorithm to optimize the problem with delivery arrival time restriction and tests with a public benchmark test set [22-23].

Because of the limited real business data availability, despite the countless investigations in the VRP, many of them are short of testing the approach on empirical data or real cases. Hence, just few of the related previous works such as [15, 24] can demonstrate a working prototype where the proposed algorithms actually work on practical geographical input data. Furthermore, even though most of the proposed approaches are recognized to have the ability to solve a specific problem on mathematical model, usually the solutions are very complex and expensive in terms of computation.

D. Research Objective

This paper wants to put a forward into the field by introducing a practical methodology to optimize the routing of convenience stores' distribution process, especially in Japan. By utilizing the web-scraping technique to collect geographical data of all of the convenience stores and gas stations in Japan (nearly 100,000 real locations), this research aims to propose a practical solution and benchmark with whole population of real data, rather than mathematical theory and synthetic simulation.

Specifically, the research implements systematic computer software and a working web-based application so as to have the postal code of a distribution network entered by a user, and optimize traveling time of drivers delivering products from a warehouse to the network that includes up-to-8 convenience stores, pass by a gas stations on the route when needed, collect all the garbage and return to the warehouse to complete the process. In this problem, we recognize the practical need of searching for an optimal location of a gas station for the delivery trucks' re-fueling along the trip, which to the best of our knowledge, has not been introduced in the literature so far.

Moreover, the software is further tested with convenience stores networks of over 1500 areas (with different postal codes) in Oita prefecture where the authors reside. Furthermore, industry-proven Google API service is also introduced in order to ensure the retrieval of the real-time traffic data used in the optimization process, as well as to reduce the dependence on high-performing computational infrastructure. Despite the fact that no time window constraints are introduced in the optimization process, the output result already includes all of the estimation of travelling duration under real-time traffic condition, hence facilitating a confident measurement of appropriate departure and arrival point of time.

Additionally, the cluster-first-route-second ideology, which has been proposed by many researches in optimizing multi-depot VRP [25-26], can be used to cope up with the convenience stores' distribution problem. Because in real-life practice, prior to optimizing the product delivery routing of a certain convenience stores network, a process of clustering all of the stores located within a region (city or prefecture) into small distribution networks in a way that can minimize comprehensive travelling duration are necessary. Even though the paper concentrates more on the later one in the workflow, which is optimizing a certain convenience store network, a proposed solution using network modeling and Evolution algorithm on Solver add-in of Microsoft Excel [27-28] is also demonstrated to optimize the convenience stores clustering in the first procedure.

III. Methodology

This section examines the distribution problem of convenience stores as a specific case of vehicle routing problems with the objective of finding an optimal delivery route that minimizes gas consumption by reducing the travelling time of trucks distributing goods from the warehouse to several convenience stores, passing by a gas station to refuel and coming back to the warehouse. Different from method approaching the original problem of the Travelling Salesmen Problem, the approach proposed here focuses more on the actual travel time, rather than physical distance optimization.

A. Network Flow Model

1) Graphical Model of the Problem

The convenience stores' distribution optimization problem is examined as a "Network Flow Problem" by assuming each of physical locations in the distributing routes as a node in the network, distance and travelling duration as weights of arches. *The* network's optimization objective is therefore to find the flow connecting every node that associates with the optimal transportation time. A graphical network flow model of a simple convenience store distribution problem involving a warehouse, and 4 convenience stores can be represented as shown in Figures 1, 2 and 3.

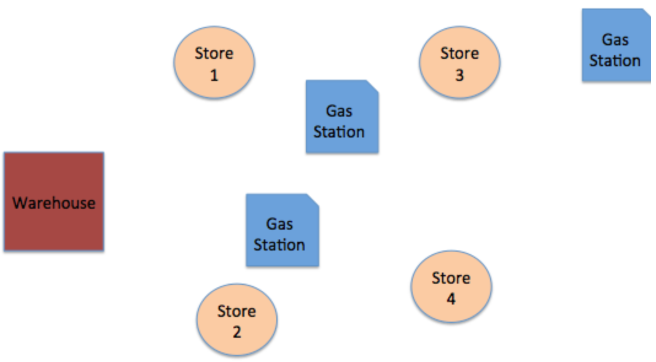

Fig. 1. Each location in the problem is demonstrated as a node in the network flow model.

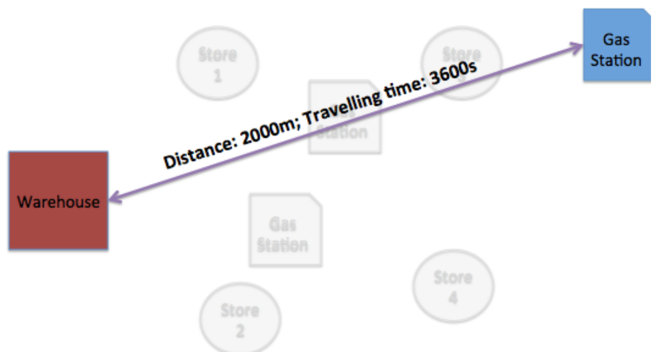

Fig. 2. The arc connecting two nodes represent the physical distance, or the travelling time needed to move between the two respective locations.

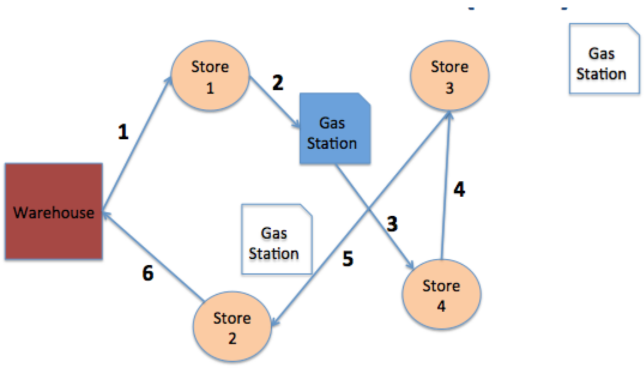

Fig. 3. Blue lines represent the flow connecting nodes and arcs, showing one of many possible routes that can help to achieve the distribution process.

2) Linear Programming Model of the Problem

A linear programming model of the stated convenience stores' distribution problem of a specific stores network can be represented as shown in Figure 4:

Notation for each node:
$a_1, a_2, a_3, .., a_n$

Arc weight between node:
a_i and a_j: $Weight(a_i, a_j)$

Whether exist a flow from node a_i to node a_j:
$Flow(a_i, a_j) = 1(exist)|Flow(a_i, a_j) = 0(non-exist)$

Minimize:
$z = \sum_{i=1}^{n} \sum_{j=1}^{n} Flow(a_i, a_j) Weight(a_i, a_j)$

Fig. 4. Mathematical Representation of Network Flow Model of Convenience Store Problem.

In order to solve this Network Flow optimization problem, collecting information about geographical locations of convenience stores, gas stations, warehouses and garbage dumpsites, as well as the distance and travel time between these locations is indispensable.

B. Data Collection with Web Scraping

To solve the distribution problem of convenience store, i.e., the Network Flow problem above, location data of all of the convenience stores, gas stations, as well as the physical distance and travelling time between those places are necessary. Thus where to find trustworthy sources and how to obtain the data are questions that are discussed in this section of the paper.

1) Data Source

NAVITIME website is established by the NAVITIME Japan Company, a Japanese online portal service focusing on events and places. NAVITIME website presents a friendly GUI (http://www.navitime.co.jp), enabling user not only access detailed information but also navigate routes between thousands of places classified into several categories such as convenience stores, gas stations, restaurants, parking places, schools, clinics and so on. Furthermore, the website also updates newly established spots in Japan, making it more reliable as a references source [29]. As far as data needed to solve the convenience store business problem, the NAVITIME website has lists of almost all of the convenience stores located in Japan, with details such as the store name, address, telephone number, and even the information regarding whether the store sells alcohol, cigarettes or fresh vegetables. Moreover, the website also classifies the convenience stores based on their location in a prefecture or city (e.g., Oita, Beppu) and brand names (e.g., 7-eleven, Lawson, etc.), making it very convenient to find the needed data. Hence, we have selected the NAVITIME website as the main data source for retrieving the geographical information of all of the convenience stores, gas stations in Japan.

2) Collecting Data from NAVITIME Website by Web Scraping

Web scraping or web crawling techniques are usually programmed to interact with a webpage source and extract data stored in it, and “usually, the extracted data might be post-processed, converted in the most structured format and stored for further usage” [30]. This research mainly relies on NAVITIME website for its data source, and web scraping programming technique as the tool to extract the data from the website. Despite the fact that NAVITIME website contains the necessary information for the convenience store distribution problem, the website is only built for normal users who would utilize web browsers to retrieve information on a single physical spot, convenience store or gas stations in this case. In other words, it would require huge amounts of efforts to manually surf the website and collect all of the data for nearly 100,000 locations of convenience stores and gas stations in Japan. Therefore, a systematic and automatic manner of retrieving the data from the website is indispensable, and web scraping technique is undeniably the most promising tool that can help us achieve this.

In order to achieve this, we developed a web-scraping algorithm for crawling data from the NAVITIME website in Ruby programming language and Figure 5 shows its pseudo code. The website categorizes all the convenience stores into different prefectures in Japan, and after accessing each of the link of those prefectures, the website shows all the links, each of which connects to a specific convenience store’s information page, sorted into different listing pages. Therefore, a looping algorithm is used to access this hierarchical structure, which simultaneously extract all the needed information of convenience store such as the store name, geographical address, telephone number, and details regarding the availability of fresh vegetables, alcohol or cigarettes, etc., and store them into a local comma-separated values (CSV) file.

```
Web Scraping on NAVITIME Website;
Result: CSV Database File
repeat
    repeat
        repeat
            Access each store's link;
            Extract the store information;
            Append the extracted data into the result CSV file;
            Return to the previous list page;
        until The last store of the list;
        Access the next list page;
    until The last listing page;
    Access the next prefecture listing page
until The last prefecture listing page;
```

Fig. 5. Pseudo code of web-scraping algorithm for the NAVITIME website.

C. Multi-objective Route Optimization with Google API

1) Google API Service

Google API is a well-known web service that provides online tools for developers who utilize Google’s data and platform. Google API consists of several programming libraries serving many areas such as Mapping, Advertising, Cloud storage, etc. Google Direction API is one such service that helps retrieve geographical distance and travelling time from one physical location to another. Moreover, the free version of such service also helps to calculate the optimal route in terms of time to travel through a maximum of 10 physical locations (including the origin and destination locations) [31]. Since Google Direction API operates on the Google server by receiving requests from the users and returning back the results, we can easily utilize the well-established platform of Google server.

Due to the academic nature of this research, we utilized the free version of the Google API service to solve the stated problem despite its limitations. For commercial application, however, the Work version of the service is recommended since in addition to a more generous number of request permits, it also provides the travelling duration and calculates optimal route under real-time traffic conditions, something which can further ensure optimality of the approach.

2) Optimize Convenience Stores Distribution Routing with Google API

In order to use Google API service, a structural request for fulfilling parameter requirements need to be sent to the Google server through a specific URL, which is designated by the service. Consequently, Google API will return the result in a response package. A typical request to Google Direction API to find an optimal travelling route for a trip includes:

- *Origin Point:* The origin location point from where the trip starts: e.g., the warehouse or distribution center.
- *Waypoints:* A list of all geographical points to pass-by during the trip: e.g., all the convenience stores in the network and a nearby gas station.
- *Destination point:* The final destination point where the trip ends: e.g., the warehouse or distribution center.

In order to find the optimal location of a gas station to fulfill the possible re-fueling requirement of the delivery vehicle, an iterative algorithm has been built. Within the collected data of all gas stations in Japan, we first want to find a list of all gas stations located within the same region as the distribution network of convenience stores. This task is obtained by looking up the area name of the distribution network (e.g. prefecture, city and town name) from the input postal code through a web API service (i.e., http://zipcloud.ibsnet.co.jp), and then the result is used as the keywords for searching relevant gas stations in the collected data. After that, each of the returned gas stations is inserted into the request waypoint parameter of Google API service, one by one, and from the returned routing results the optimal one is selected. This route then becomes the optimal one that passes through all the convenience stores in a desired network and at the same time drops by the gas station for re-fueling.

D. Cluster-first-route-second

Cluster-first-route-second is a heuristic method for optimizing large scale VRP, which has two separate phrases, namely clustering and routing. Originally, the algorithm was intended to address problems with vehicle capacity constraints. However, this idea of classifying all the waypoints into different clusters before optimizing the route has been adopted in many practical research questions such as in VRP with Backhauls [32].

In convenience stores business, daily-consumed products have to be delivered to every store on a regular basis. For example, 7-eleven convenience stores have rice and chilled products delivered three times per day, and drinks and frozen foods delivered three to seven times per week [2]. Hence, all of the customers or convenience stores in this case, have the same orders at similar time intervals during a day or a week. This implies that distribution network of a distribution manager who is in charge of hundreds of stores within a city or a prefecture is usually much larger than a chain of convenience stores that can be handled by a single delivery truck. Applying the idea of cluster-first-route-second approach will allow distribution managers to first cluster all of the stores that fall within their delivery network into many small networks in a way that can both satisfy total number of available delivery trucks and optimize the total travel time durations of their respective network. In this section we have utilized free Google Distance Matrix API to obtain the travel time matrix among convenience stores, a sample result of which are shown in Figure 6, and used Evolutionary Algorithm of Solver add-ins on Excel for solution demonstration. As an example, two networks consisting of all the 7-eleven and Family-Mart convenience stores in Beppu City, Oita Prefecture has been selected to illustrate the approach.

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Address		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
別府駅	1	0	499	963	440	762	130	250	600	315	864	765	942	604	430	72
大分県別府市石垣東7丁目2055	2	503	0	740	207	374	443	563	207	462	470	633	767	382	286	59
大分県別府市大字鶴見字石田91番1	3	1024	705	0	847	595	967	998	609	1012	418	601	423	873	688	25
大分県別府市新港町4番15号	4	418	216	838	0	443	491	546	304	294	568	751	865	284	344	70
大分県別府市上人西2組1	5	717	312	598	462	0	722	845	226	593	328	791	625	301	551	56
大分県別府市田の湯町8番13号	6	166	494	941	515	762	0	120	595	390	859	743	920	679	425	70
大分県別府市光町21番18号	7	315	609	939	589	897	168	0	720	501	936	784	857	752	477	69
大分県別府市石垣西10丁目4-54	8	603	152	592	294	209	568	688	0	479	322	628	619	320	360	50
大分県別府市北浜3丁目818-166	9	303	478	1018	314	636	359	351	497	0	761	820	1026	478	466	77
大分県別府市大字鉄輪693番4	10	863	412	424	554	302	821	941	316	739	0	609	451	579	603	38
大分県別府市大字鶴見字五反4207-1	11	821	610	595	704	753	764	848	603	809	593	0	824	866	485	35
大分県別府市竹の内1895-15	12	913	693	411	835	583	860	842	597	927	405	820	0	860	732	46
大分県別府市上人ケ浜1412番6	13	544	322	842	320	303	617	672	308	420	572	878	869	0	551	75
大分県別府市石垣西3丁目5番8号	14	445	290	684	310	537	385	505	360	441	602	486	776	529	0	44
大分県別府市大 4組2	15	775	564	241	658	531	718	749	485	763	371	352	470	749	439	

Fig. 6. Travelling time duration matrix of network including a warehouse at Beppu station, and fourteen 7-eleven convenience stores in Beppu City.

The Evolutionary Algorithm with default parameters setting is run on linear programming models manually built in Excel. The optimization objective is set to minimize the total traveling duration in the whole network with a single warehouse. Decision variables show the total stores in each group, the classification of each convenience store, as well as the traveling order. Constraints of the problem are the constant number of available delivery trucks (or the total number of groups), and an assumption that each groups must contain more than two stores. Moreover, the warehouse is assumed to be located at the central station of the city.

For better illustration, visualization Google maps are generated by an online tool (https://mapbuildr.com) to show the clustering and routing result of the real-life networks of 7-eleven (14 stores shown on Figure 7) and Family-Mart (16 stores shown on Figure 8) convenience stores in Beppu City, Oita Prefecture. Moreover, each cluster is marked with distinguish colored dot on the map with the traveling numerical order within the cluster being placed inside, and the big balloon-shaped red mark represents the warehouse.

E. Web-based Implementation on Mobile Platform for Continuous Routing Updates

Although at the cluster-first-route-second stage, optimal delivery sequence of stores assigned to each delivery truck is calculated, the situation may change during the actual delivery time due to traffic congestion. The ultimate goal of this work is to also build a practical mobile application that can interact with truck drivers in a programmatic manner and enable them to input any references regarding a specific convenience store distribution network. The device should then automatically run the underlying procedures all the way from finding the necessary data to sending requests to Google API service and retrieving the calculated optimal delivery routes through an easy to follow GUI in a real time fashion. This way, the mobile device of the truck drivers can serve as navigation system for the delivery network, calculate optimal delivery route in a continuous fashion and update the truck drivers about a possible re-route option when deemed necessary. To achieve such an objective, a prototype of web-based mobile application and local web server have been established and developed using PHP, HTML5, JavaScript on Angular Framework, and MySQL database management and the following subsections highlights its main features.

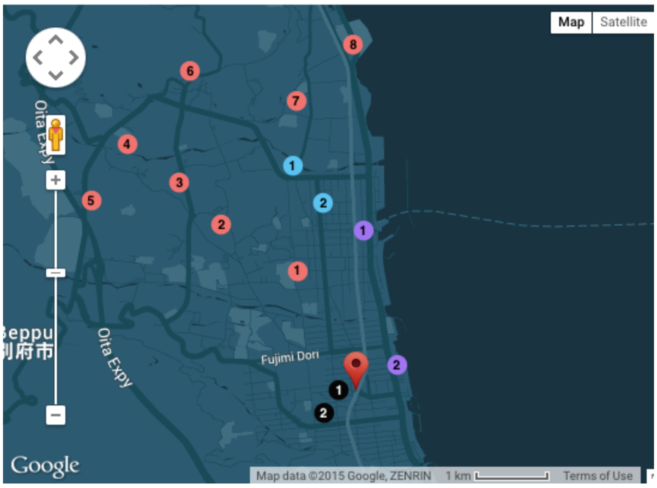

Fig. 7. Clustering with 4 groups (black, purple, blue, and red) and numerical routing order of network consisting of all of fourteen 7-eleven convenience stores located in Beppu City, Oita Prefecture.

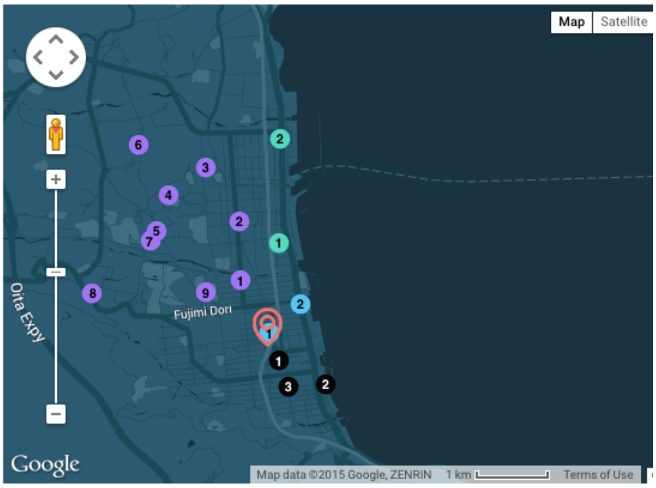

Fig. 8. Clustering with 4 groups (black, blue, green, and purple) and numerical routing order of network consisting of all of 16 Family-Mart convenience stores located in Beppu City, Oita Prefecture.

1) Navigation System Structure

A block diagram of the envisioned system is shown in Figure 9. It is a large online network consisting of a web

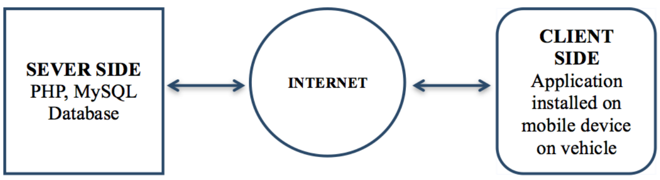

Fig. 9. Structure of the proposed navigation system.

server and various clients, which are mobile devices running the web-based application and available in each delivery truck. The web server's responsibilities include managing the retrieved database and sending geographical location of convenience stores and gas stations located in a requested distribution network, or geographical region. Because of the centralization of the server's database, the system can maintain consistency of response to every client in case there are modifications to any of convenience stores' information. This way, clients will act as bridge to search for convenience stores between the user and central sever. Furthermore, the mobile devices installed in the delivery vehicles will support the drivers by displaying an interactive navigation map, which is based on the familiar Google Map platform, illustrating its familiar perception of up-to-date optimal route for a customizable distribution network.

2) Graphical User Interface & Functions of Client Application

Mobiles are selected as target devices due to their built-in GPS functionality, which can facilitate real-time navigation tracking for the equipped delivery trucks. As such, the process of route optimization can be done not just statically before starting the trip, but also dynamically while the truck is moving. This way, the remaining route gets continuously optimized based on the current traffic condition.

The two figures 10 and 11 demonstrate the developed web-based application running on iOS simulator. Figure 10 shows the page requiring necessary input from the user for searching a list of convenience stores located within a specific region, which is specified by postal code. In this GUI, warehouse location, as well as the intention to re-fuel is also customizable. Figure 11 gives an example of the search result page, letting the user to select up-to 8 convenience stores (7 in the case of passing by a gas station for re-fueling) into their distribution network. Then, Figure 12 shows the result of a navigation map, guiding the distribution route with numbered markers (Gas station marker has "S" suffixed), representing

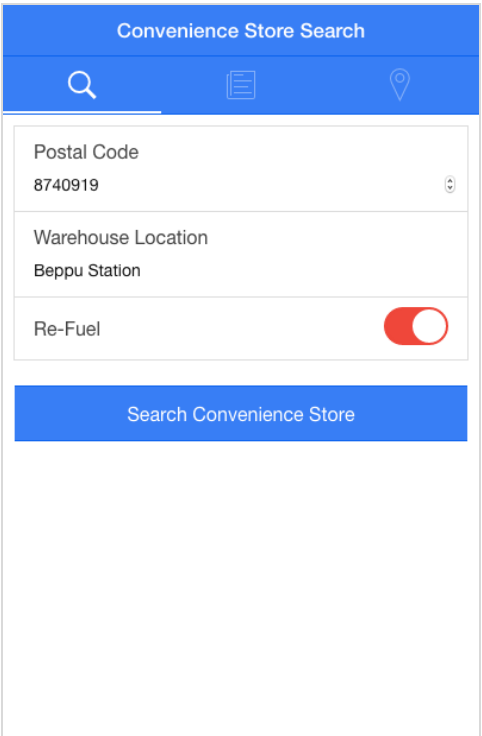

Fig. 10. GUI for showing search result of convenience stores located in an input area (through postal code).

Fig. 11. GUI for showing search result of convenience stores located in an input area (through postal code).

the travelling order, which starts from "0" at 1st delivery point.

As the delivery truck moves, the application automatically verifies whether it has reached a predefined place (e.g. Figure 11) on the route or not. This way, the application has the capability to continuously build a new network, which consists of the current location as new origin, and remaining stores and a gas station (if the truck has not yet passed by one) as the waypoints, without any manual input from the driver. Whenever the driver clicks the "Update" button shown on Figure 12, a new route is also immediately calculated together with the latest traffic condition from Google API service. As

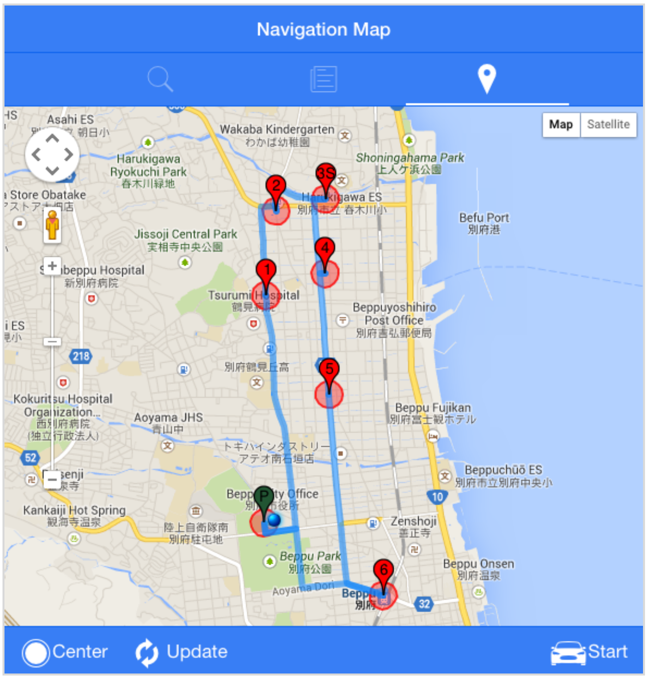

Fig. 12. GUI showing the navigation map with the optimal route calculated and shown. The blue dot represents the current location of the truck, and green marker labeled "P" indicates if the truck has already passed the location.

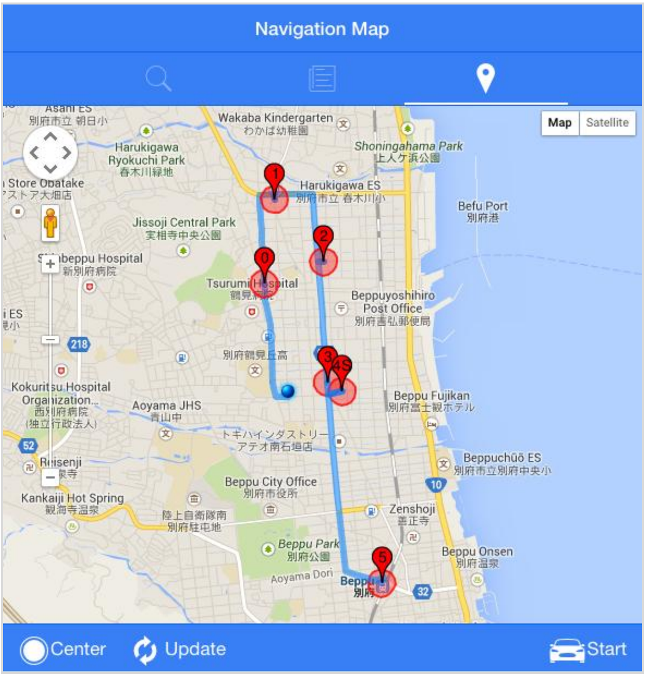

Fig. 13. GUI showing the updated navigation map for optimal route starting from the current location of the truck and passing by all the remaining convenience stores from the initial network.

shown in Figure 13, after the driver has passed the first location and is on the way to the next convenience store (location numbered 1 in Figure 12), a new route is calculated. Please note that in addition to the renumbering of the remaining delivery nodes, optimal gas station location has been altered from previous location labeled "3S" in Figure 12 to a new location labeled "4S" in Figure 13 due to current traffic situation.

IV. Analysis and Discussion

This section provides a thorough analysis of the obtained results and discusses the advantage of implemented methodology in some details. Initially, the envisioned positive impacts of the obtained result are examined from both economical and environmental perspectives. Then some figures illustrating the outcome of the data collection procedure is demonstrated. Several verification test results on the feasibility of the developed computer software are also illustrated. Finally, accuracy and performance of the proposed approach is compared with other well-known methodologies.

A. *Commercial and Environmental Perspective*

To examine the economical and environmental benefit of our approach, we collected some relevant data on convenience stores in Japan (e.g., the total number of convenience stores, the average number of deliveries per day, etc.) and made several assumption scenarios. For each of the scenario, financial cost saving and carbon dioxide emission prevention were calculated with the aid of online gas consumption calculator tool at http://www.city-data.com/gas/gas.php, which also considers the gas consumption differences between city roads and highways.

Collected Data and Pertinent Assumptions:

- Number of convenience stores in Japan: 56,925
- Average number of deliveries needed to a single store per day: 9
- Average number of convenience stores in a single distribution network, or average number of convenience stores to which a single truck has to deliver a day: 8
- Average hourly salary of a single truck driver: 900 Japanese Yen
- Average fuel cost per gallon: 115 Japanese Yen
- Miles per gallon in city: 30
- Miles per gallon in highway: 40

Based on these assumptions, an example network of eight 7-eleven stores in Beppu City, Oita Prefecture was initially tested with the program. Using the obtained result and by comparing two possible trips with a maximum and minimum travel distance, a heuristic estimation of maximum cost saving and carbon dioxide emission prevention for every convenience stores network in Japan is estimated. Our finding shows that approximately 2.8 billion Japanese Yen can be saved per year, which is equivalent to 56 million tons of carbon dioxide, or roughly 7.8 million homes' electricity for one year. Even though this estimate may not be precise due to location disparity of convenience stores throughout Japan, we can still see the huge impact of the approach in real life practice.

B. *Data Collection and Program Testing Result*

1) *Data Collection*

Informational on about 57,000 convenience stores and roughly 40,000 gas stations was collected using web data scraping technique on the NAVITIME website (http://navitime.co.jp). Table 1 shows a summary result of the specific number of physical places, total time needed for data extraction, and actual size of the CSV files in which the extracted data are stored:

TABLE I
EXTRACTION TIME OF CONVENIENCE STORES AND GAS STATIONS' PERTINENT DATA USING RUBY SCRIPT AND NOKOGIRI LIBRARY

Data	Convenience Store	Gas Station
Number of Locations	56,925	36,660
Extraction Time	96 minutes	80 minutes
CSV File Size	16.3 MB	14 MB

Considering that our analytical approach depends on the extracted information on all the available convenience stores and gas stations in Japan (nearly 100,000 physical locations in total), the data crawling had to be done on nearly 100,000 web pages. This may give an impression that the above mentioned processing time for data extraction is quite expensive. Nonetheless, because all of the extracted information, e.g., store names, addresses, etc. is almost fixed and does not easily change; the created CSV file can be subsequently used as database for optimization for quite sometimes and enable the system to operate in real time fashion. Therefore, the extraction time of one and a half hours for a periodical update of the database can be considered practically acceptable. Furthermore, despite some limitations of the CSV file utilization for data storage which is discussed in the limitation section, the CSV database file size of about 15 MB is feasible for a typical ruby program to execute any necessary reading or writing operations.

2) *Program Testing*

In order to test correct operation and reliability of a newly developed program, we initially used it to gather various data on roughly 56,925 convenience stores and 39,660 gas stations that are located throughout Japan. We then focused our analytical modeling approach to convenience stores that are located in Oita prefecture. Our finding shows that out of 1,765 different districts in Oita prefecture that have a unique postal code, (a complete list of which can be accessed from the link http://homepage1.nifty.com/tabotabo/pzips/oita.htm), in 754 or 42% of them there exit convenience stores. We then created examples of convenient store networks with up-to 8 stores per network for supply and garbage collection services and in about 95% of them the program could come up with an optimal routing solution in less than 1 minute.

C. Accuracy & Performance

In general, routing optimization problem requires much time and computational resources in order to come up with a feasible solution. In this particular case, since optimization problem consisted of a network having a warehouse, up to 8 convenience stores, and a garbage dumpsite, our algorithm had to examine a total of 40,320 possible routes in determining an optimal solution that could yield the least travel duration or distance. Even though there are many proven algorithms such as Evolutionary or Generic algorithm to solve the routing optimization problem, their analysis in general takes longer time.

This was realized when we validated optimality of our result with that of Evolutionary algorithm built into Excel's Solver Add-in function using its default settings. Although both methods yielded the same result in terms of optimality, performance of our approach which relies on Google API is much faster than that of the Evolutionary algorithm built into Excel's Solver Add-in function, as shown in Table 2. Despite the fact that free version of Google API service is limited to a network of 10 nodes, its enterprise version can handle a network of up to 25 nodes per request.

TABLE II
PERFORMANCE COMPARISON BETWEEN GOOGLE API SERVICE AND EVOLUTIONARY ALGORITHM OF EXCEL SOLVER ADD-IN

Testing Network	Evolutionary Algorithm in Excel Solver Add-in (approximately)	Google API Service
Network of 6 locations	42 seconds	Less than 10 seconds
Network of 7 locations	51 seconds	Less than 10 seconds
Network of 8 locations	52 seconds	Less than 10 seconds
Network of 9 locations	53 seconds	Less than 10 seconds
Network of 10 locations	58 seconds	Less than 10 seconds

D. Cluster-first-route-second Performance

There have been many different ways approaching the cluster-first-route-second heuristic in solving VRP. However, many of them failed to consider the traveling time duration based on real-traffic condition at the time, something that is crucial for true optimization. Our test results shown in Figures 6 and 7 were achieved by Solver add-in in Excel within 1 minute, a performance that is a reasonable in terms of computation time for a network of less than 20 convenience stores within a city. With the usage of Google API for Work to access the distance matrix for real-traffic condition and some further customization of the Evolutionary Algorithm's parameters, this approach can also deal with a large scale network in bigger cities or in a whole prefecture that use multiple warehouses to cater to the needs of convenience stores.

E. Mobile Application Prototype

The developed prototype has been tested on modern browsers, including Chrome mobile on Android and Safari on iOS. Its performance has also been validated with several cases of user input (postal codes, warehouse location, and re-fueling necessity), and with all the cases of distribution network of convenience stores in Beppu City, the application has delivered optimal routing solutions. Moreover, thanks to the mobile device simulation function of desktop Chrome browser, the application has also been tested with different manual GPS locations to simulate continuous movement of vehicles. With the rapid development of silicon technologies, these days portable devices with large screen and high quality display are becoming more affordable. As such, this prototype is developed with the aim of integrating science and technology to come up with a practical solution to a real business problem. Such strategy will be used in our ongoing and future studies and it is hoped that other researchers will also pursue a similar trend.

V. CONCLUSION, LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This paper raises the awareness of utilizing available technology and programming techniques to attain commercial goal in convenience stores business, and simultaneously take the perspective of CSR into consideration. This research proposes practical methodologies for solving the convenience stores' distribution problem of optimizing product delivering route from a warehouse to several convenience stores, passing by a gas station for re-fueling, and returning back to the warehouse. The approach involves collecting geographical location dataset of about 100,000 real-life convenience stores and gas stations, a web-based mobile application for practical implementing of Google API service and creating database to solve the problem. Specially, a more general view of the convenience stores problem, which recognizes the empirical necessity of dividing a fix number of drivers to many small convenience stores distribution network, is introduced and resolved by using Evolutionary Algorithm of Solver on Excel. Overall, considering its reliability and fast performance, the approach can be extended for practical applications of not only convenience stores' business, but also in other businesses that are looking for advancements in supply chain management.

The followings can be considered limitations and some relevant future research directions.

1) Current web scraping technique strongly replies on the NAVITIME website structure. Specifically, the introduced web scarping technique uses a tree-based algorithm to extract data at pre-indicated tag position. Because of this, when the HTML tags structure of the webpage with the needed data changes, the technique may not work properly. To enhance this, development of an algorithm with artificial intelligence ability, such as the learning-based web wrapper algorithm, may be necessary so as to cope with possible structural changes to the NAVITIME website.
2) The analytical approach of this paper heavily relies on Google API service. Considering the academic nature of the work, however, the developed prototype was only tested with the free version of Google API service which

imposes certain limitation on the number of requests per day. Nonetheless, such limitation can be overcome by utilizing the Google API for Work, which facilitates up to 100,000 requests per day. Moreover, since the Google API for Work also supports calculation of optimal route with waypoints within real-time traffic condition, its usage will ensure a much more reliable result.

3) Although the recommended approach provides a practical solution for the convenience stores' distribution problem with the goal of optimizing the delivery time, which would result in reduction of gas consumption; the problem can also be examined under a pattern learning perspective to have an inner sight into the convenience stores' distribution process. Specifically speaking, apart from travelling time, there are also many other factors that contributes to the gas consumption during the product delivering process, namely; weather, temperature, route terrain, vehicle driving speed, etc. However, not all such factors can be easily controlled and calculated. A promising approach would be to collect data on such factors' impacts on the volume of gas consumption and apply machine-learning techniques so as to understand the patterns of how much each of such factors could contribute to the actual gas consumption. Then, an algorithm that also takes these factors into consideration can be developed. Moreover, because the data is expectedly retrieved in real-time, the learning pattern could be continuously updated to ensure the most pragmatic suggestion. To obtain this, the research promotes further examination into not only pattern learning techniques, but also ubiquitous and sensor network for real-time data collection.

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Thai Quang LE was born in Khanh Hoa Province, Vietnam in 1993. He is presently pursuing his studies at Ritsumeikan Asia Pacific University (APU) in the field of Business Administration focusing on Strategic Management and candidate for graduation. He has received numerous scholarships including, APU Tuition Reduction Scholarship from 2011-2015, JASSO (Japan Student Services Organization) Scholarship from 2011-2012, and Oita Prefecture Scholarship in 2012-2013, 2014-2015. His research interests include applied programming in business, modeling for decision-making and machine learning, on which he has carried out a few presentations. The theme of his thesis is retail activity optimization and he has become an IEEE member since 2014.

Davar Pishva is a professor in ICT at the College of Asia Pacific Studies, Ritsumeikan Asia Pacific University (APU) Japan. In teaching, he has been focusing on information security, technology management, VBA for modelers, structured decision making and carries out his lectures in an applied manner. In research, his current interests include biometrics; e-learning, environmentally sound and ICT enhanced technologies. Dr. Pishva received his PhD degree in System Engineering from Mie University, Japan. He is Secretary General of IAAPS (International Association for Asia Pacific Studies), Senior Member of IEEE, and a member of IEICE (Institute of Electronics Information & Communication Engineers), IAAPS and University & College Management Association.

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Global IT Research Institute

1713 Obelisk, 216 Seohyunno, Bundang-gu, Sungnam Kyunggi-do, Republic of Korea 463-824

Business Licence Number : 220-82-07506, Contact: secretariat@icact.org Tel: +82-70-4146-4991