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Collaboration Interface in Smart Metering Scheme

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Abstract

Smart meter provides intelligence to serve demand side management. The development of electrical-load-signature technology provides an effective base to enable condition-based monitoring and energy-collaboration management among stakeholders. In a smart metering scheme, the three direct contributors are supplier, estate manager and consumer. Affiliated members are appliance manufacturers and sustainability managers. It is perceived that when a platform can be developed to permit members sharing information, trading benefits, and recommending energy plans. The development of a collaboration interface is to assist the principal members in supporting each other as neighboring aide in these activities. This paper discusses on philosophies and models that shall develop the concepts; and shares the development of this interface.

Keywords: smart meter, demand side management, electrical load signature, supplier-estate-consumer interface.

1. INTRODUCTION

A meter is an information interface between the service-provider and the service-consumer. When the meter carries intelligence, it is a smart meter. When the meter utilizes this intelligence for betterment, it is a manger.

A smart metering system is an upstream to downstream collaboration model for power networks. It matches quality home demand with quality power generation through collaborative trading efforts between the parties through well designed interfaces. The parties involved contribute operational information ethically and legally; and through processing of information, come by requests and advices to improve system operational quality and efficiency. The terms quality and efficiency in this context are generic. They may expand to cover environmental, energy management and demand-side maintenance management, despite details of these areas are beyond the detail of this paper.

In order to earn the greatest success, the model shall be an incentive-derivative-trading model in Fig 1, with partnership in a value channel [1] connecting supply-side management with demand-side management.

The channel potential value-partners are identified, and each is built with compatible intelligence. With pleasing offer, the smart metering scheme encourages the partners to manage the use of electricity for public interests. This may include a well-planned generation at the upstream, to an efficient appliance at the downstream. The most effective platform must be real-time operative.

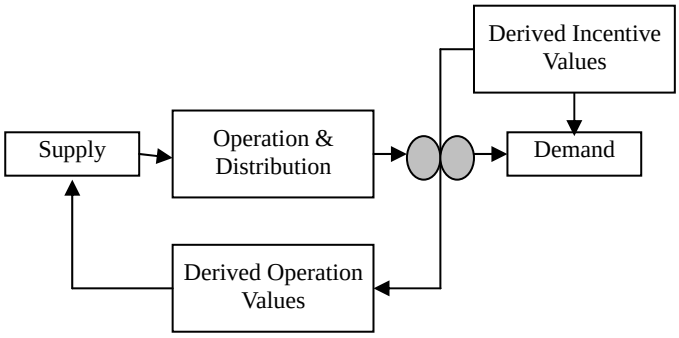

Fig 1 Incentive derivative

This paper discusses on the collaboration interfaces among the various partnerships.

2. PARTNERS, PERSPECTIVES AND BENEFITS

The scheme promotes downstream users, which are the estates and the homes, to develop demand-side management and link it with the supply-side management.

The scheme utilizes the value channel model [6], and invites all possible channel contributors to join the scheme so that value is enhanced throughout the channel. The major potential collaborators will be the supplier; estate management offices; electricity-users; installation contractors; and appliance manufacturers. Nonetheless, the contractors are assumed to perform tasks to specification only. Hence they are not included in the study.

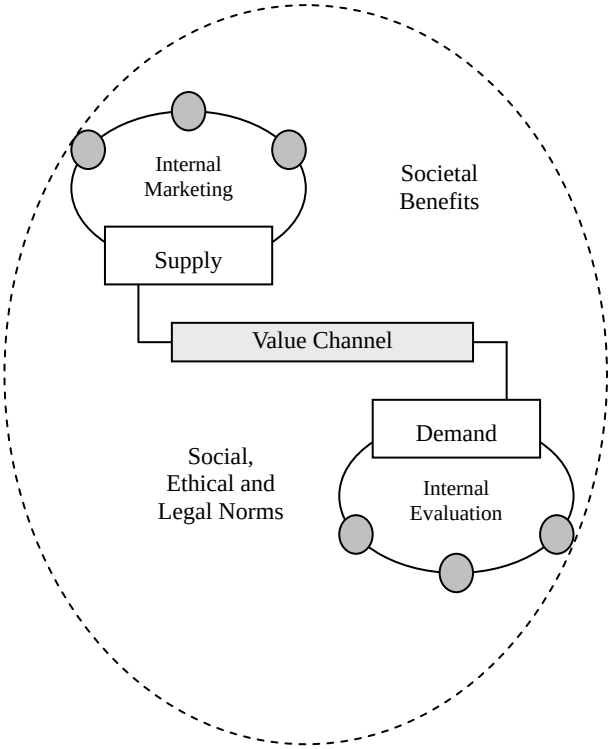

Fig 2 Value Channel

As proposed by Lee and Fung [1], links are established in a value channel to enable partners offering incentives and accepting benefits between each relationship pair. The incentives and benefits can be tangible or intangible; and can be individualistic or societal.

Along the channel, the partners are different entities. Hence they have different scopes of concerns and hence may plead for benefits differently. For this reason, a trading model has to be developed. Lee and Fung [1] gave a detail of the possible benefits which could be useful for future smart metering development. Such development must also aim for betterment of the society at no expense to social and ethical norms.

3. MODELS AND ARCHITECTURE

3.1 Collaboration structure

The computerized consoles of the three direct potential collaborators, explicitly the supplier; the estate management offices; and electricity-users, are named respectively as the Power-Flow Administrator or the Administrator; the Estate Managers and the Home Managers. Homes cover offices and industrial premises.

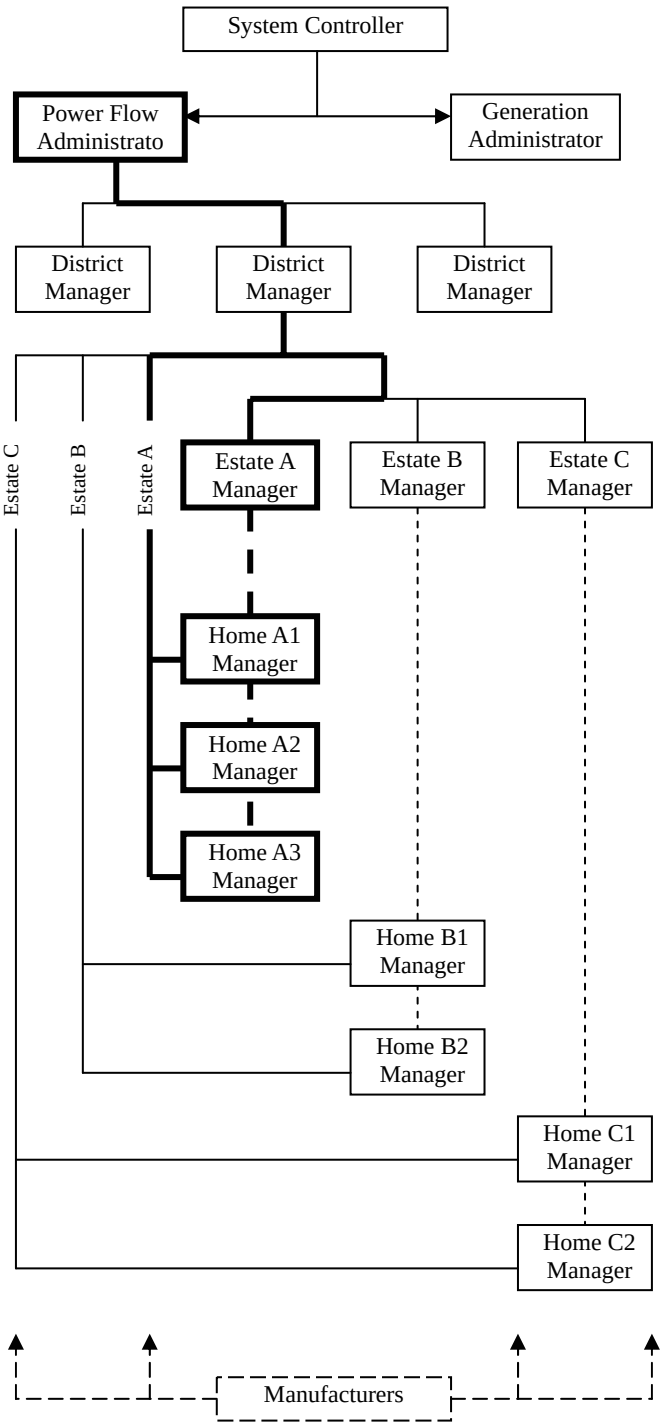

Fig 3 General structure of collaboration

The collaboration structure is a virtual organization in which the members share common societal beneficial culture, and agree to goals for which they pledge to exhibit passion.

As members are not in a real organization, they are value partners on the same authority platform. Referring to Fig 3, the lines in the structure indicate relationship, and the levels of the boxes indicate the weight of influence. In other words, it represents expert/referent power and never as position authority. In other words, the power-flow administrator cannot force, but only to influence the home managers or estate managers to follow their proposals even when the former has a crucial need. Nonetheless, there are rules and agreements that can be set of pre-set to induce efficiency of collaboration, and to avoid disputes. The rules follow criteria determined jointly by the parties, and the agreements spell out the trading incentives among these direct partners.

The indirect partners like contractors and appliance manufacturers are regulated by market-forces on a social plus legal platform.

Despite partners are given equal rights, the success of the virtual organization and the scheme requires an effective span of influence similar to the span of control in a real organization. For this reason, the administrator must delegate the overseeing responsibilities to district managers, and must determine the algorithms of prioritizing the estate managers and home managers. After all, the homes are constructed to be linked to their respective estates, and hence they can also earn communal benefits through good participation of the estate management in the smart metering scheme.

3.2 Collaboration roles

The power-flow administrator works directly for the supplier. He is the controller of the smart metering system. For this reason, he should be well aware of the effects of system parameters in respect of power delivery operation, environmental protection, and other social norms. The administrator should have management skill and ability to deal with both planned and crisis operation. At the first stage of scheme development, a high degree of innovation for popular trading of benefits is also expected.

Estate managers are electricity users as well as intermediate agents. They play a remarkable role in the value channel in a one-stone for two-bird manner. There are three types of estates: commercial, industrial and domestic estates. Their electricity consumption patterns are different. The estates are large sinks of electrical energy, and provide sub-infra-structure between the supply network and the homes under their respective management. Hence they carry the potential to adjust load diversity in a bulk manner; and may represent the homes to bargain collectively for communal benefits. With a referent influence, their recommendation of smart metering scheme to the homes may also alleviate the supplier's effort in promoting the same. In addition, as they are agents, they also carry obligation to collect opinions and feedback to the partnership for further system improvement.

Homes are electricity users and perform in the scheme as individuals. Whilst a single home consumption is generally small, the aggregate consumption of this sector of partners is substantial, and may significantly disturb power system performance positively or negatively. To enhance home participation in the smart metering scheme, education of new societal culture and formulation of a reward system for developing trading habits are required. The rewards include discount on electricity bill, cash rebate, renewal coupon, and technical consultation, etc. as suggested by Lee and Fung [1]. The home managers should have intelligence and ability to control appliances of the respective homes. The feasibility requires expertise compliance through the contractors and appliance manufacturers by sign-up or load signature approach [5].

The scheme will finally help majority electricity users to adopt a green energy consumption culture that enable sustainability and efficiency of resources.

3.3 Basic Technical Structure

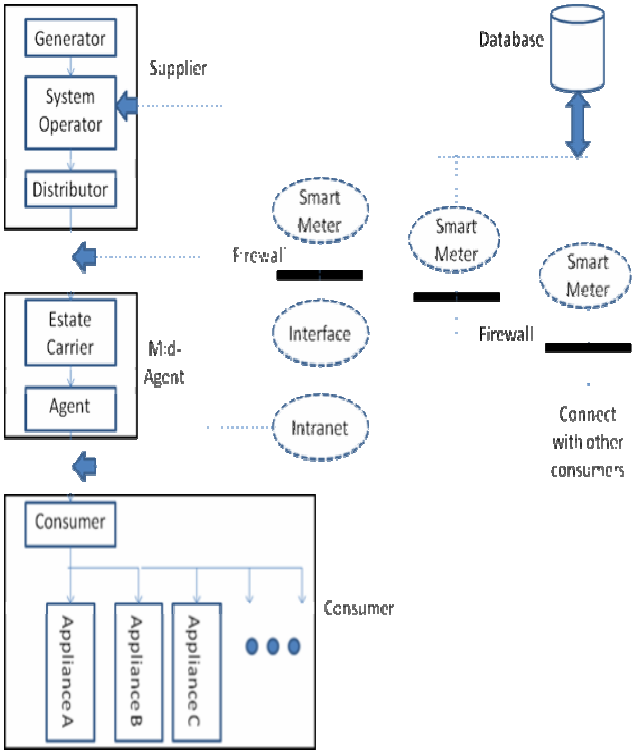

Fig 4 Architecture of hardware system component

The technology supporting a smart metering scheme must be able to collect, to process, to interpret, to retrieve, to inquire, to response, to select, to decide, and to act effectively and timely. As shown in Fig 4, the smart metering system carries bi-directional carriers linking the three direct partners that represent: the supplier; the mid-agent; and the consumer. The supplier functions for generation, system operation and energy delivery at the up-stream. Connecting to the up-stream, the estate is the neck that commences the down-stream. Enjoying the sub-infra-structure provided by the estate, and the energy delivery from the supplier, the home is technically linked to both the estate and the supplier.

Based on the relationships, a carrier network and an intranet platform are built, and compatibility of intelligence is built among the individual partners. Since they are partners in a virtual organization, each member is permitted to get access to the intranet under well-defined protocol. The supplier is usually the intranet administrator and the other members may earn the access through authorization and contractual agreement with the supplier. In most cases, the agreement also stipulates terms by which the supplier may manipulate operation of home circuits in critical load through a good trading.

The architecture of the software manipulation is as Fig 5. The collection of technologies has to take care of the relationship, security, friendliness, powerfulness, integration, connectivity and compatibility, In view of large demand of connectivity, LifeCycle Data Service (LCDS) is an alternative to BlazeDS.

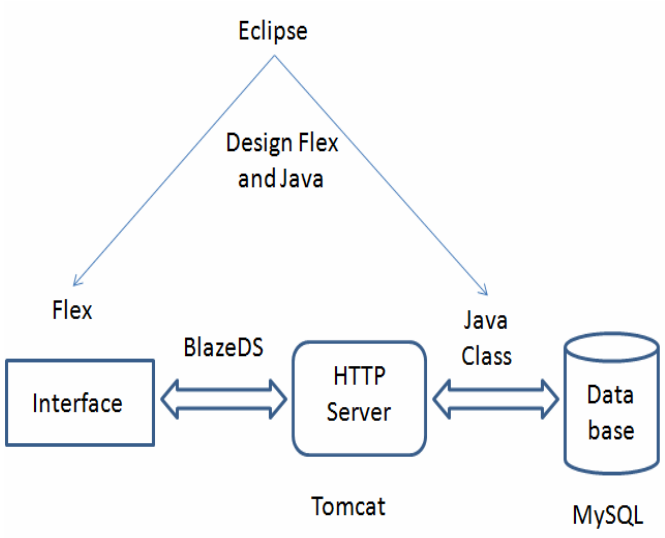

Fig 5 Architecture of the software system

4. INTERFACE AND DATABASE DESIGN

4.1Man-Machine interface

Whilst most of the data collection, processing and actuation are computerized and programmed, man-machine interaction is essential to cope with trading offers and acceptances arise from time to time. Moreover, man decision is required when an action rule is floating. A proper interface enables the parties to be informed of advices, consumption statistic, and summary of actions, etc. in respect of his account.

A home page is available to direct partners to earn access to relevant and dedicated pages. Between an estate manager and all participative home managers in the estate, read-only pages carrying real-time statistic and periodic summary of the estate performance are also accessible.

The following characteristics are essential in a man-machine interface:

1. User-friendly: It should be designed to avoid users' frustration, fear and failure; and it must induce proximity to users. The layout and content must be simple and focus to alert sustainability opportunities. It prompts the user at appropriate times, and without nuisance to his life. The maintenance support must also be user-friendly.

2. Safe and secure: The user habits and agreements have to be protected from all third parties. Between a home and an estate in a partnership, still only authorized information can be accessed between the two partners. Since the system has control and instruction capability, hence it must prevent any tampering access.

3. Informative and responsive: The user is well informed, or can have full access, to statistic and analysis of his personal account, his trading commitment, and his earning to encourage responses for positive partnership.

4. Real-time: Trading must be bid, collected, and processed on real-time. Real-time advices based on real-time consumption statistic may facilitate faster response from the user.

5. Stable and reliable: The system links with power quality and cost. Any interruption or error in the system may drag out to a great loss, and may lead to disputes.

Fig 6 and Fig 7 together show an example of the flow of an estate manager's panel man-machine display in respect of a scheme proposed action. Flow of other interfaces are also considered.

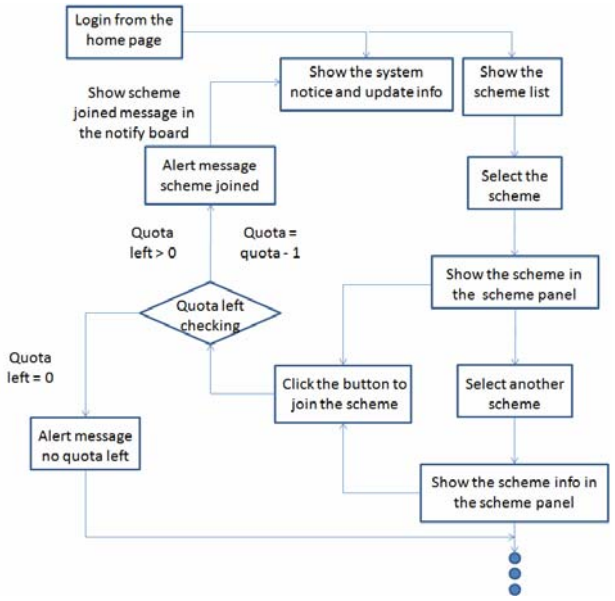

Fig 6 Flow chart of a scheme proposed action

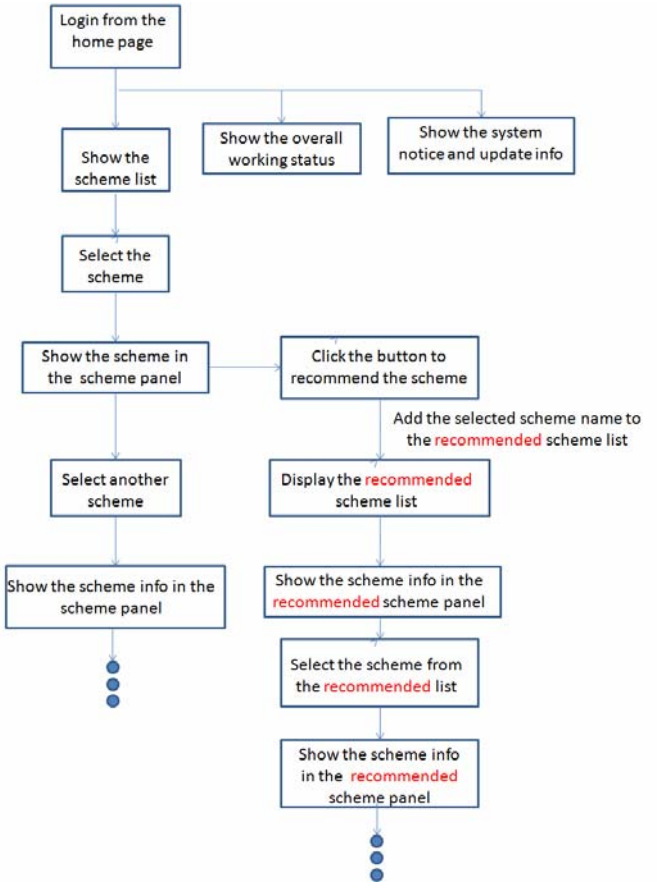

Fig 7 Flow chart of estate manager interface

4.2 Machine-Machine interface

Machine-machine means that the process is usually automated, yet for some actions, there are manual-over-rides.

All the partners in a line of the channel, namely: the administrator, an estate manager, and a home manager, have machine intelligence. The administrator is assigned to system strategic intelligence; the estate manager to tactical intelligence; and the home manager to operational intelligence. In other words, operational actuators and sensors should be local, and the home managers have full control on their performance.

The smart meters, which serve the registration of power consumption, are the interfaces for both energy and signals. Each of the meters has an energy carrier and a data communication carrier. These carriers connect the administrator and the corresponding consumer only, and not to any third parties including our partners in the scheme. A smart meter has local intelligence, and as an interface, it can also tap information provided by the aforementioned sensors.

Standards and compatibility are highly desirable between the administrator and the managers, as the downstream managers, namely estate managers and home managers, are also expected to perform equipment automation functions in their own and respective installations.

Agreed principles, rules and terms that also follow the law; ethics; and public interests; are applied to the automation if they are feasible. Terms covering over-ride control at crisis can also be automated to ensure its effectiveness. The rules also allocate the roles and tasks of individual machines; and their limitation of performance. In other words: dedicated do's and dont's are assigned to individual machines. The estimation of quota and the priorities of offer, acceptance and execution must be centralized by the administrator central console; despite distributed implementation can be commissioned to the district managers.

Again, the machine-machine interface must be safe, secure, stable and reliable. And to cope with possible machine failure and maintenance, therefore as aforementioned, a manual-over-ride must be installed.

5. CONCLUSION

Meter is an interface between the supplier and the consumer, and present technology enables it to bear responsibilities much higher than its traditional registration duty. It is a tendency of 21st century to utilize intelligent, clean and efficient electricity. Smart metering system helps this

concern through more transparency in sharing information and trading benefits among the parties in the value channel. It calls for partnership beyond the conventional relationship and builds a new triangular supplier-estate-customer relationship. Collaboration and partnership build win-win-win scenarios, plus promoting the society in a sustainable manner.

These are the first set of contribution of smart metering. In future, when local smart-grid systems are developed, it is envisaged that smart metering shall give further contribution in collaborating the major supplier and the local smart-grid suppliers.

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