

Family System: A Reference Model for Developing Home Automation Applications

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Abstract—This research is a pioneer attempt to establish theoretical foundation and a framework for technical developments in Home Automation. This study suggests the need for an International Technology Roadmap for Home Automation (ITRHA) to formulate a need based vision of typically 10 to 15 years and stresses the need for HA to cater for the specific requirements of family home users. The concept of Family Life Cycle is used to understand the temporal needs of family. In order to formally describe a coherent set of family processes, their relationships, and interaction with external elements, a reference model named *Family System* is established that identifies *External Entities*, 7 major processes, and 7 subsystems to manage smooth functioning of these processes by allocating resources and interfacing between processes and *External Entities*. The *Family System* reference model can be used to conduct detailed requirement analysis and thus identify potential HA products and services meeting realistic user needs.

I. INTRODUCTION

Home Automation (HA) has emerged as a prominent field for researchers and investors. Nevertheless, many products and services offered by HA are yet to reach the average home user. Review of past developments reveals that the HA Industry needs well founded user requirement analysis, clearly defined scope and a long term goal to exploit the large market potential. It is essential for the HA Industry to formulate strategic plans based on the “big picture” of family home life and realistic user needs. A bottom up approach following task level automation has been used till date in developments of products. As a result of this approach contributions of the HA Industry have been mainly limited to three areas that are Home Networking and Remote Control of appliances [1], [2], [3], Entertainment [4], and Building environmental control – Heating, Ventilation, Air Conditioning (HVAC), Lighting, and Security.

An International Technology Roadmap for Home Automation (ITRHA) is required for formulating industry level strategic plans with a futuristic vision in the range of 10 to 15 years [5]. Technology Roadmapping is the process of need based identification of products and services, technology alternatives, technology gaps and creating technology investment plans [6]. This process produces a Technology Roadmap (TR) that becomes the reference document for organizations or corporations in achieving the set goal. The

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first phase in Technology Roadmapping is defining scope and boundaries of the roadmap and this can be established by analyzing the targeted system. Effective automation can be achieved by distinguishing processes that are time consuming, laborious, complex, or repetitive in nature.

This study is the initial part of a pioneer attempt to formulate theoretical foundation to the application of technology to the field of HA by creating an initial Technology Roadmap. Therefore, the primary step required is to define the targeted system that can be further decomposed into products, subsystems, and or components using systems analysis. Critical functions/features to be accomplished by identified products/components can be used to derive technology needs and many technology areas that can be involved in accomplishing those critical features. A systemic approach has not been followed in past developments in HA and due to this reason a full system view is unavailable. It is required to define a system encompassing over all aspects of HA providing full system view that can be used for further analysis and decomposition.

This paper presents a reference model named *Family System* for the purpose of formally defining the scope, boundaries and describing the processes, and communication of the family. The *Family System* can be used to identify products and services meeting realistic user needs. Section II defines the family and home user as well as the concept of Family Life Cycle to depict the dynamism and temporal requirements of a family. Section III defines the boundary of the *Family System*, entities external to Family System, illustrates the interaction of *Family System* with external entities and identifies processes within *Family System*. Section IV identifies subsystems managing these processes.

II. FAMILY FOCUS

In Home Automation Industry, “home” is almost interchangeably used to refer to a family as well as a dwelling place. Before proceeding further it is important to distinguish between the words home and family. The theoretical definition of home is a dwelling place and generally used for a building where people live.

A. Family

Definition 2.1: Family is referred to as the traditional structured society consisting of one or two parents and their children.

Any person belonging to this structured society is called a family member.

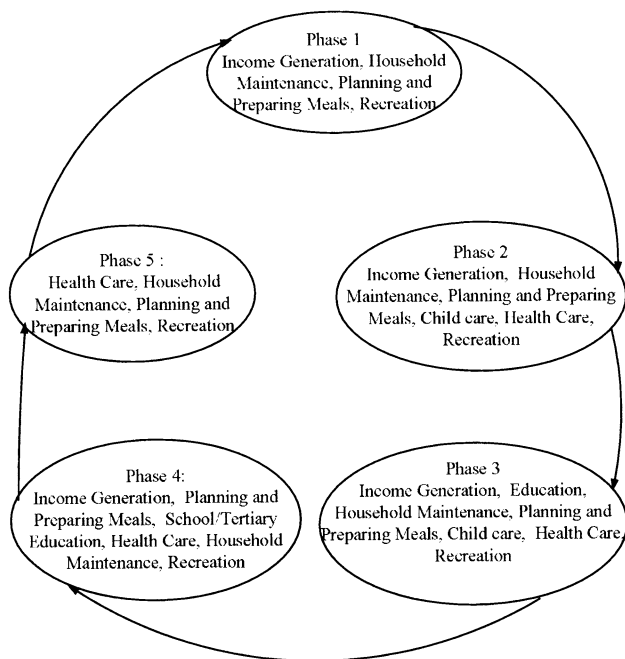


Fig. 1. Family Life Cycle: Different Phases and Prominent Responsibilities in Each Phase

Definition 2.2: *Home User* is any person who owns and or occupies a home and uses the products and services of HA industry.

A *Home User* is not necessarily a family member, but a family member is a home user. A *Home User* occupying a house in one location can be a family member of a family located in another geographic location that may be in another country.

Family is a dynamic system moving through time and members of a family share history and future with at least three and often four or even five generations [7]. The concept of Family Life Cycle is used to identify important stages in family life as it evolves through time. Understanding distinguishable stages of the family life are necessary to obtain insight into varying functionalities and resulting alterations in requirements.

B. Family Life Cycle

Union of two committed adults marks the beginning of the Family Life Cycle. A family has a growing stage when responsibilities keep increasing due to child birth, schooling etc. and it goes through a shrinking stage when responsibilities reduce as members are lost due to death or adult members leave the family to start independent life resulting in extended family. This paper accounts *family* as a mobile unit and a *family* may occupy different houses located in various parts of the world for reasons such as business, employment, or education. In this study the Family Life Cycle is defined with the following distinguishable phases:

- Phase One: Union of Committed Couple. In this phase main responsibilities of the couple are earning income, maintaining a balanced diet and recreation.

- Phase Two: Family with young child/children. Phase Two is marked with the addition of children to the family bringing increased responsibilities of child care. Health care becomes more complex with extra tasks and the same applies to maintenance of balanced diet.
- Phase Three: Family with school-going children. In Phase Three the family is confronted with additional responsibility as the child or children commence schooling. A family in this phase could have very demanding responsibilities in terms of time and resources as child care needs of younger children can be overlapping with school education of elder ones.
- Phase Four: Family with adolescents. This can be considered as the beginning of shrinking stage as the child care responsibilities are completed. Strategic management of time and money are critical in this phase to satisfy the requirements of children involved in formal education and extra-curricular activities.
- Phase Five: Family in later life [7]. Retired couple have lesser responsibilities compared to the family in previous phases. Health care becomes an important aspect as well as social life.

The progress of family through phase one to phase five engaging in various areas of responsibilities are illustrated in Fig. 1.

III. FAMILY SYSTEM REFERENCE MODEL

This section introduces the model named *Family System* by depicting *Family* as one system interacting with elements outside family. The reference model defines the terminology, and concepts as well as identifies important processes, communication and subsystems. Process modelling has been the chosen approach for defining the model and data flow diagram following Gane and Sarson symbol set is used for communicating the model as this provides the most suitable technique to depict the whole system, its boundary, entities, processes and interaction with external systems [8], [9]. Due to limitation in space this paper presents only the context level view and the next level with subsystems and interaction between subsystems. The model is not a design specification for an actual system; rather it provides a framework that defines the targeted system for Technology Roadmapping purpose.

The *Family System* (FS) exists in an environment and systems external to FS impact the performance of the FS. The environment of FS can be understood by identifying systems external to Family and the interaction of FS with those systems or elements.

Definition 3.1: An *External Entity* is any functional unit that provides and or receives any form of service or goods to the family and is not part of the *Family*.

Definition 3.2: *Data flow* is any input received or any output sent by the *Family System*, subsystems or processes within *Family System* that can be represented in electronic form.

Definition 3.3: *Resource flow* is any material input received or any output sent by the *Family System*, subsystems

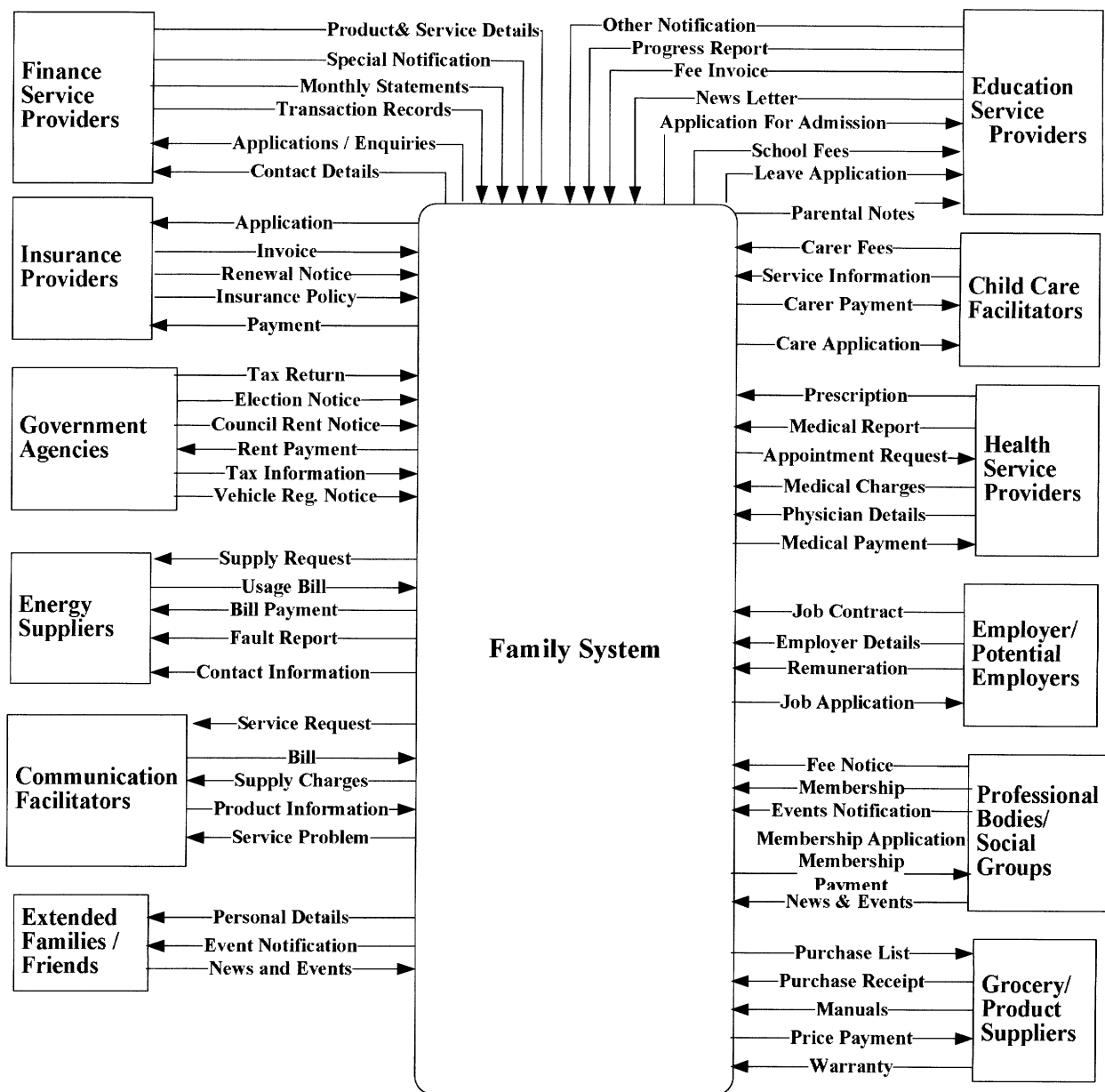


Fig. 2. Interaction of Family System with External Entities

or processes within *Family System* that cannot be represented, stored or transmitted in electronic form via a computer network.

There are variations to the number of services used by the *Family* and the *External Entities* in different phases of the Family Life Cycle. For the modelling purpose a *Family* in Phase 3 is considered as this phase is at the top of growing stage having increased complexity in processing and information usage. Based on this and the definitions above, *External Entities* considered are: Finance Service Providers, Insurance Providers, Energy Suppliers, Health Service Providers, Government Agencies, Education Service Providers, Child Care Facilitators, Professional Bodies, Employer / Potential Employers, Communication Facilitators, Product Suppliers, Extended Families and Friends, and Re-

ligious/Social Groups. An *External Entity* can be added or removed from the environment of FS based on its interaction with the *Family System*.

1) *Interaction of Family System with External Entities*: An overall view of the Family System interacting with External Entities is depicted by identifying the *Data flows* as shown in Fig. 2. Understanding the *Data flows* between the *Family System* and the *External Entities* can be used to analyse the volume and frequency of data communication leading to information management tasks. Resource flows are not shown at this level of the model for clarity and simplicity.

A. FAMILY SYSTEM PROCESSES

Definition 3.4: A *Family Process* is a set of related activities carried out by family member/s providing input to

produce defined output and this can be done regularly or occasionally.

Even though *Family Process* is defined in perspective of *Family* most of the processes identified can be altered to meet the needs of other home users who do not belong to structured families. There are seven family processes identified and these are briefly described below.

1) *Managing Finance:*

Definition 3.5: Managing Finance includes all activities carried out by family members individually or in group that are money related.

These activities include making payments to *External Entities*, receiving remuneration, budgeting, monitoring expenditure, account keeping, investing and strategic planning on income generation and spending. Information management tasks of data collection, recording, and reporting as well as knowledge extraction and decision making play a major role in *Managing Finance* that is essential for a happy and successful family life. Statistical data show that twenty-five percent of Australian households experienced at least one cash flow problem in the previous 12 months period [10].

2) *Planning and Preparing Meals:*

Definition 3.6: Planning and Preparing Meals includes all activities carried out by family member/s individually or in group that are related to food.

These activities include administering grocery shopping list, purchase, storage, deciding menu for meals, cooking and cleaning kitchen area and utensils. Meals include main meals as well as snacks and drinks consumed by members of the family as per customs or practices followed. Collecting and storing complete information on food products, recipes and mapping them to the individual needs of family members is necessary to formulate a regular balanced diet.

3) *Family Health Care:*

Definition 3.7: Family Health Care includes all activities carried out by family member/s individually or in group to ensure good health for each of the family members.

These activities include monitoring health check parameters such as weight, blood pressure etc., consulting doctor, obtaining vaccinations, purchase and consumption of medicine, monitoring of diet and exercise, and maintaining health records. Other tasks included are personal care, maintenance of appropriate clothing, and body hygiene. Generally health records remain with health practitioners and medical history of a person may be scattered among different health practitioners in different geographical locations.

4) *Education:*

Definition 3.8: Education includes all activities undertaken by family members in organising, maintaining and completing the formal school and or tertiary education.

Children's education is a major responsibility for parents and it can span a period of twenty years or more in case of a family with more than one child. Adult members of the family updating their skills can also be part of this process. During this period parents are responsible for maintaining regular communication receiving forms, newsletters, periodical progress reports, invoices, and other similar communi-

cations from Education Service Providers. It is also required to monitor regularly school events, schedule time to attend required events and provide assistance with home studies, get money allocated and monitor academic performance.

5) *Household Maintenance:*

Definition 3.9: Household Maintenance includes all activities carried out by family member/s to maintain a house that is functioning well to provide a safe and comfortable environment for the family.

The house may be owner occupied, leased or rented. Main tasks involved are organising utility services, paying bills, recording equipment purchase details and bills payment, organising insurance and premium payment, monitoring and control lighting, security and HVAC, undertaking cleaning and repairs of household appliances, and organising supply of consumables and other amenities.

6) *Generating Income:*

Definition 3.10: Generating Income includes all activities carried out by family member/s to identify, obtain, prosper and maintain occupation with remuneration.

Adult members in a Family are engaged in occupation. This could be a business run by the Family and in this case, custom made software is generally used for various aspects of the system. This study considers cases where member/s of the family are engaged in paid employment. This necessitates recording employer details, preparing applications and resume, and storing appointment letters and other formal notifications received from employer, recording and maintaining potential employers' list, and monitoring job market.

7) *Recreation and Social Life Maintenance:*

Definition 3.11: Recreation and Social life Maintenance includes all activities undertaken by family members to organise entertainment activities, and maintain social life.

This process is responsible for maintaining contacts with extended families, social groups, and friends, and organising sporting activities and holiday trips. Most important task is to record contact details, important events (birthdays, anniversaries etc.), update details, and record important correspondence. Producing reminders at appropriate time and guiding on time scheduling to attend events are also part of this process.

IV. SUBSYSTEMS WITHIN THE FAMILY SYSTEM

The main Family System is divided into seven subsystems such that each one of the processes described above is managed by one subsystem. Process operation requires resources and interface to send/receive input/output. The subsystem is responsible for resource management for the smooth execution of the process and has the necessary interface allowing interaction with other processes and relevant *External Entities*. The subsystems considered are: Finance, Housing, Meals, Health, Education, Career, and Recreation and Socialization.

Each of these subsystems interfaces with one or more other subsystems for the overall smooth functioning of the *Family System*. The subsystems identified and data flows between

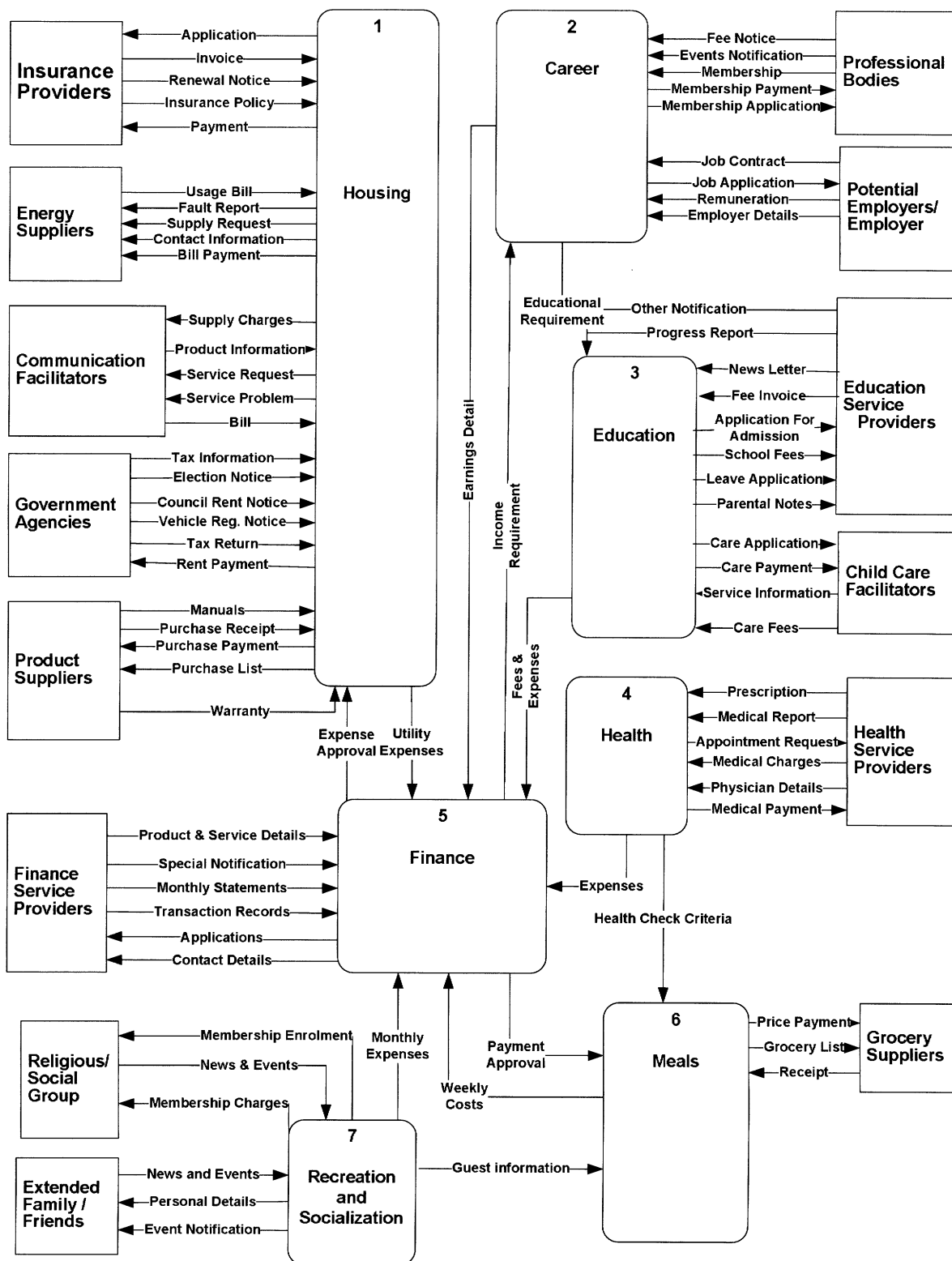


Fig. 3. Subsystems Within Family System

subsystems and External Entities are illustrated in Fig. 3. The following paragraphs briefly describe each of the above mentioned subsystems.

A. Finance Subsystem

Finance Subsystem is responsible for the smooth functioning of all sub processes and tasks within the process of *Managing Finance*. Additionally, this subsystem has the logical data storage and interfaces to interact with all other subsystems to monitor income and expenses and produce appropriate control signals.

B. Meals Subsystem

Meals Subsystem is responsible for the smooth running of *Planning and Preparing Meals*. Meals subsystem has to co-ordinate with the Finance Subsystem to ensure spending on Food within budget and it is required to co-ordinate with the Health Subsystem to ensure appropriate diet within the measures of Health Care. This subsystem has to co-ordinate with *Recreation and Socialization* subsystem to extract information for the correct planning of meals on occasions when people other than family members are present.

C. Health Subsystem

Health Subsystem is responsible for the smooth running of Health Care process and all the sub processes within Health Care. *Health Subsystem* has to co-ordinate with other subsystems such as *Finance* and *Meals* and has to communicate with related *External Entities*. This subsystem has the logical data storage facilities to collect and record available health related documents and information.

D. Education Subsystem

Education Subsystem is responsible for all the processes and sub processes under Education. This subsystem interfaces with *Finance Subsystem* to provide information on expenses related to education as well as budgeting and receives input from *Finance Subsystem* to control expenses. Data storage facilities to record and access all education related documents as well as interfacing facilities enabling interaction with *External Entities* also forms part of this system.

E. Career Subsystem

Career Subsystem is responsible for the coordination and execution of the process of *Generating Income* and necessary sub processes, resource management and allocation, and interfacing with external entities as well as other subsystems such as Education.

F. Recreation and Socialization Subsystem

Recreation and Socialization Subsystem is responsible for the management of *Recreation and Social life Maintenance* process, resources required for this process, and interfacing with the *Health Subsystem*.

G. Housing Subsystem

The *Housing Subsystem* manages the process of *Household Maintenance* and this involves interfacing with Finance Subsystem to receive input on budget and send details of expenses. The Housing Subsystem interacts with *External Entities* such as Insurance providers, Energy Suppliers, Product suppliers, Communication Facilitators and Govt. Agencies.

V. CONCLUSION

The *Family System* exposes the important processes within family and interaction with *External Entities*. The linkage of process usage to different stages of family life can be used to formulate taxonomy of home users based on behaviour rather than demographics. The model of FS can be used for further detailed analysis to explore products and services for process automation, information management, and decision support to assist home users in every day life. This is the seed for triggering broader Roadmap for HA by extracting information on technology needs, technology alternatives and technology gaps.

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