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Future User Requirement Elicitation for Technology Investment: A Formal Approach

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***Abstract*—This study addresses the lack of methods to systematically identify future market needs for strategic planning in technology investment. Uncertain and ambiguous future, hardly available user input on realistic needs, market with latent demand and evolving market increase technology investment risk. The authors presents a formal approach named Requirement Elicitation of Future Users by Systems Scenarios (REFUSS) that derives future user requirements by relating process knowledge obtained from current system model with plausible future user lifestyle related information obtained from scenarios. Scenarios developed in a cause-effect way by identifying and correlating a number of environmental factors assists strategists to learn about plausible changes and be prepared for any unexpected shift. The REFUSS fills a gap by providing a simple and applicable method for future user requirement elicitation. This can be used for formulating needs based vision thus avoiding project failures from following technology based vision.**

***Index Terms*—Future study, technology investment, scenario, user requirement elicitation, scenario technique, strategic planning, home automation**

I. Introduction

Technology Investment can be risky due to the long time span involved between investment and product marketing, lack of user input on realistic needs, and evolution of the market. An example is the home automation market that is consistently experimented by using trial and error methods to market new products following technology based vision. This has led to many project failures and unsuccessful ventures [1], [2].

Lack of formal methods to systematically derive the future market needs to exploit the available market potential is the major problem. The market consists of users having very diverse characteristics demographically, socially, culturally and economically. Researchers using user involved methods to derive market needs have achieved very limited results exposing only partial image of the whole picture. The diversity, uniqueness and distinctive nature of users disallow a group think and collective request or demand originating from the users.

Traditionally, users actively involve in user requirement analysis where the product/service is an essential component for the activity users are primarily engaged in. In many cases application of technologies is not required for the primary activity of the users. However, the users are confronted with many lifestyle related problems that are difficult to handle without technology assistance resulting in a latent demand. Simultaneously, the users generally lack enough technical knowledge or insight to understand what they are missing.

Strategic planning for technology investment requires futuristic vision. As future is unknown technology investment decisions are risky due to many uncertainties and ambiguities present. Scenarios built around a number of factors, issues, and interaction between them provide a means to visualise different plausible futures and use this vision to learn, think and carry out further research on the evolving future requirement in core technology investments [3]. The alternative visions assist the strategists to explore a range of futures with richly detailed information so that they can be prepared for any surprising shift from the expected future.

This study presents a new method named Requirement Elicitation of Future Users by Systems Scenarios (REFUSS) that relates the process knowledge, obtained from the system model, with future user lifestyle related information from scenarios, for deriving future market needs for strategic planning in technology investment. This study has applied scenario technique to understand plausible future lifestyles of home users and the market drivers influencing these lifestyles. Van der Heijden's approach is followed in developing scenarios [4] and this is detailed in Section III. Three scenarios developed provide insight into plausible variations to the current lifestyle trend in case of unexpected twists in some of the driving forces. Technology application needs are identified by deriving the list of processes having *Demanding Process Attributes* for the users with *User Characteristics* related to the most likely scenario.

The REFUSS uses three components that are:

- A system modeling the current processes within the system, input and output of the processes
- Scenarios depicting future lifestyle and plausible user characteristics
- Generic rules relating process attributes to user characteristics.

Section II details a method to formally define the processes and establishes the formal definition of users that can be used to relate logically the user and process. Section III describes the application of scenario technique to derive future lifestyle and derive user characteristics. Section IV formalises the identifica-

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tion of processes for technology application by systematically relating the defined properties of users and processes. Section V demonstrates the application of this method to identify future home user requirements for automation.

II. Definition of Process and User

The purpose here is to understand the processes within the targeted system from the user's point of view using generic and simple terms. The interest here is only in those operational aspects of the process that are detrimental to the effective completion of the process and those need to be supported by the user. Such operational process requirements have a direct impact on the process use by specific user. The current process knowledge is the basis. To achieve this, it is essential to have a system model depicting processes, input/output and operational requirement of the process. The system model is developed by incorporating all basic and essential processes that are less time variant.

Let S_P be the identified system, and $\mathbf{P}$ be the set of processes within the system:

$$\mathbf{P} = \{p_0, \cdot, \cdot, p_i, \cdot, \cdot, p_n\} \quad (1)$$

where p_i represents a process, $0 < i \leq n$.

A. Process Description

This study proceeds to define process using most generic terms that will not be affected by the resources used for the process or system related factors. A number of terms are defined here for clarity and use in later steps.

Definition 2.1: Process Attribute is a variable that partially describes the nature of process from the operational perspective of the user. The *Process Attribute* is indicative of or maps to process requirement to be met by the user for effective process completion achieving desired result.

An example *Process Attribute* is frequency of use having values such as routine, intermittent, or infrequent; this implies the nature of user interaction required for the smooth running of the process. From the developed system model and collected process knowledge all the processes are listed with corresponding *Process Attributes*.

Let a_i be the set of *Process Attributes* for a particular process p_i and this can be represented by the set given below.

$$a_i = \{a_{i0}, \cdot, \cdot, a_{ij}, \cdot, \cdot, a_{in}\} \quad (2)$$

where $0 < j \leq n$.

For every process p_i in the set of identified processes $\mathbf{P}$ there exists a number of *Process Attributes* and this set is defined below.

$$A = \{\forall p_i \mid p_i \in \mathbf{P} \bullet \exists a_i \mid a_{ij} \in a_i \land 0 < i \leq n, 0 < j \leq n \bullet a_{ij}\} \quad (3)$$

Each *Process Attribute* of a process maps to one or more operational requirement to be satisfied by the user. Let r_{ij} be the set of operational requirements for a particular process p_i having *Process Attribute* a_{ij} and this can be represented by the set given below.

$$r_{ij} = \{r_{ij0}, \cdot, \cdot, r_{ijk}, \cdot, \cdot, r_{ijn}\} \quad (4)$$

where $0 < k \leq n$.

These operational requirements are to be met by the user.

B. User Description

Two aspects need to be derived for the definition of user: the current user and the evolution of the future user. The purpose here is to understand and define the user in simple and generic terms such that the process and user could be related. This study refers to users as individuals or family members who belong to a wider society.

Definition 2.2: User Characteristic is a variable that partially describes the state of a user. The range of values is dependent on the lifestyle followed and it influences the use of the process.

Definition 2.3: Environmental Factor is any social, economic, political, legal, or physical resources related factors that influence the lifestyle of the user.

The lifestyle of these users are beset by many *Environmental Factors*. In turn the lifestyle has an effect on the *User Characteristic*; it is of temporal binding. An example of a *User Characteristic* is the emotional state of a user and it can take one of the values of happy, sad, stressed, or relaxed. The values of *User Characteristic*s are identified to understand the users in their daily life and thus relate to their perspective of process use.

Let $\mathbf{C}$ be the set of *User Characteristics* of a user following a lifestyle of interest.

$$\mathbf{C} = \{C_0, \cdot, C_i, \cdot, C_n\} \quad (5)$$

where C_i represents a *User Characteristic*, $0 < i \leq n$.

A *User Characteristic* indicates or maps to constraint/s a user may have, to effectively implementing a process. Let T_i be the set of constraints of a user having *User Characteristic* C_i; this could be represented by the set given below.

$$\mathbf{T_i} = \{T_{i0}, \cdot, T_{ij}, \cdot, T_{in}\} \quad (6)$$

where T_i represents set of user constraints, $0 < j \leq n$.

Definition 2.4: Demanding Process Attribute is any *Process Attribute* of specific value with associated operational requirement that constraints the user to accomplish the process in the required fashion producing quality output by a user of specific *User Characteristics*. This implies that the same rule applies for all the users having the same *User Characteristics*.

For example a process having a *Process Attribute* of frequency of use with a value of *routine* becomes a *Demanding Process Attribute* for a user with a *User Characteristic* of availability with a value *mostly unavailable*. This means that the operational requirement indicated by or associated with a *Process Attribute* corresponds to a constraint indicated by a *User Characteristic*; therefore the user is naturally incapable of meeting the process requirement appropriately. Such *Process Attributes* are termed *Demanding Process Attributes* for users with specific *User Characteristics*.

III. Derivation of Future User Characteristic

It is critical to develop understanding of future *User Characteristics* in a formal way that can be used for learning about the future market needs. The future market needs and consumer demand depends on the lifestyle that will be followed at that point of time.

Scenarios are used as a tool to learn about the future by creating "holistic and integrated images" [5], and thus provide the decision makers an exposure to major influence factors and their interactions.

The scenarios developed here are used for two purposes:

1) To systematically learn future user lifestyle, and resulting *User characteristics*
2) To provide a means to re-assess future trends in case of unexpected shift.

A. Scenario Development

Scenario development method described here is as per van der Heijden's approach [4]. Initially a large set of *Environmental Factors* that influence the lifestyle of users are taken. These factors not only influence the user, they influence each other. Factors that have a major influence on other factors are taken as high impact. Factors that are highly influenced by others become uncertain in their influence on the users due to their own variation. These are taken as highly uncertain. An NxN influence matrix is created by assigning numerical values to the amount of influence a factor can have on another factor, where N indicates the total number of factors. This matrix is used to calculate total impact or uncertainty of each of the factors.

Let $\mathbf{M}$ be the matrix. The total impact $\mathbf{I}$ of an influence factor *i* on other factors can be obtained by

$$I_i = \sum_{j=1}^{n} \mathbf{M}_{i,j} \tag{7}$$

where $\mathbf{M}_{i,j}$ represents the impact of factor i on j.

A high value of I_i is indicative of the high impact of this factor on other factors as well as on the future.

The impact of other factors $\mathbf{U}$ on an influence factor *i* can be obtained by

$$U_i = \sum_{j=1}^{n} \mathbf{M}_{j,i} \tag{8}$$

where $\mathbf{M}_{j,i}$ is the impact of factor j on i. A high value of U_i implies that *i* is less predictable or highly uncertain.

1) Scenario Dimensions: The total impact/uncertainty factors obtained from equations 7, 8 are plotted in a two dimensional graph called Impact/Predictability Graph. Factors that have extreme values become the critical influences or uncertainties as these are the most important in setting the future trends or being highly unpredictable can twist the expected trend. The major factors responsible for setting or twisting the future trends are called *driving forces*. The factors having values in the top right quarter of the Impact/Predictability Graph is of interest as these are of high impact and low predictability. These are the *critical factors*. The underlying factors influencing the critical factors are called *driving forces*; these are grouped into two that become the scenario dimensions. A horizon year is chosen as the cut-off year for the scenarios. Stories of futures are developed by contemplating the outcome of variations to the *scenario dimensions*. Three different worlds are constructed that are extremely dissimilar.

IV. Identification of Processes for Technology Application

On completion of the previous steps there is knowledge of the processes belonging to current system and the future *User Characteristics* derived from the scenarios. The requirement is to derive the processes to be targeted for technology application for the future users. These processes could be derived by relating the future *User Characteristics* with the current *Process Attributes*, as the identified processes are less time variant.

The automation requirement depends on the snap shot of *User Characteristics*, as this is a dynamic set that can acquire values from different sets. The acquired values depends largely on the lifestyle. Once a scenario is chosen with associated user lifestyle, a set of *User Characteristics* with appropriate values is generated. The generated list of *User Characteristics* is then used to derive the set of *Demanding Process Attributes*. As discussed in Section II-B a *User Characteristic* indicates or maps to constraint/s if any experienced by the users following specific lifestyle. A *Process Attribute* indicates operational requirement to be met by the user.

For every characteristic C_i in the set of identified user characteristics $\mathbf{C}$, if a corresponding constraint is an operational requirement for a process with specific *Process Attribute*, then this process is difficult to execute for the user with the specific characteristic. Such *Process Attributes* are chosen as *Demanding Process Attributes*. A process with values of *Process Attributes* matching to one or more values in the *Demanding Process Attributes* is of interest; as it is difficult for the user to accomplish this process, with the identified set of *User Characteristics*.

The relationship of User space, Process Space and derivation of processes for technology application are depicted in Figure 1. This Figure depicts a number of selected *User Characteristics* listed as C_3, C_{11}, C_{17}, and C_6. Constraints corresponding to one or more of these characteristics are shown as $T_{31}, T_{61}, T_{111}, T_{171}, T_{63}$, and T_{65}. Operational requirements for one or more of the *Process Attributes* of A_{31}, A_{40}, A_{42}, and A_{61} are shown as r_{311}, r_{401}, r_{421}, r_{312}, and r_{611}. In this example, the listed constraints are matching to the operational requirements. Therefore these *Process Attributes* are chosen as the *Demanding Process Attributes* for the selected set of *User Characteristics* that belong to the specific set of Users as indicated in the Figure 1.

A. Processes for Technology Application

The set of processes that are target for technology application are the ones with the *Process Attribute* values matching

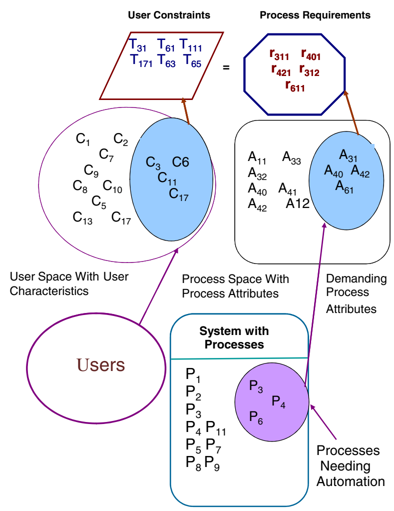

Fig. 1. Derivation of Processes for Automation

to any in the set of *Demanding Process Attributes*. Here the implication is that by understanding the factors affecting *User Characteristics* mostly from a prevalent lifestyle followed during a period of time, a sizable segment of market may have the same needs.

V. Home Automation: An Example

The demand for Home Automation (HA) products and services are invariably dependent on the home user requirements emerging from prevailing lifestyle. There are many *Environmental Factors* influencing lifestyle changes. Impact on demand for the HA products and services due to alterations to these factors, is unpredictable.

The application of the REFUSS requires a system model with identified processes. The *Family System* reference model developed by the authors is used to identify the processes [6]. Using this information the *Process Attributes* can be derived. The following section details the development of scenarios in order to formulate the future *User Characteristics*.

A. Creation of Home Lifestyle Scenarios

Scenarios are developed to understand plausible future lifestyle of home users and the major factors influencing these lifestyles. Scenarios depicting future lifestyles are developed from identifying and correlating a number of environmental factors that influence the lifestyle. The goal here is to explore plausible lifestyles that may evolve in the next ten to fifteen years. The scenarios described in the following sections have been developed following the steps described in Section III-A. Initially a large number of factors that are issues or trends are identified with the intention of detecting all *Environmental Factors* that influence home lifestyle setting trends [7]. In order to build the foundation for the different scenarios, the *Environmental Factors* listed in Table I are considered. This is not an exhaustive list and this list is filtered to accommodate only the factors that have major influence.

TABLE I
Environmental Factors

Social	Economical
Dual income families	credit card debt;
Reducing housework time	Energy cost
Employed single parents	easily available credit facility
Use of processed food	cost of education
increasing necessary services	job insecurity
Desire for more leisure time	housing cost
Diet related diseases	
prolonged formal education	
Desire for quality of life	
work pressure and stress	
increasing necessary services	
Political	**Ecological**
Globalization	Water scarcity
Dynamic job market	Resource shortage
information overload	global warming
increased mobility	carbon emission reduction

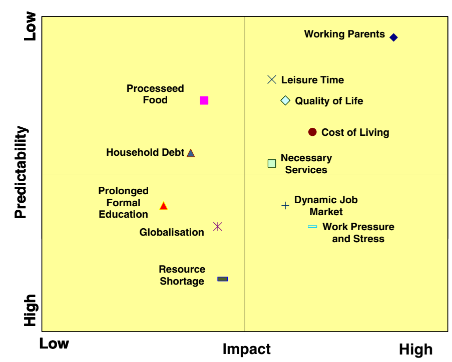

Fig. 2. Impact / Predictability Graph

An influence matrix is created as described in Section III-A. The total impact/unpredictability for each of the factors is calculated using the matrix and an Impact/Predictablity graph is created as shown in Figure 2. The critical factors are the ones of high impact and low predictability. These factors are located in the top right hand quadrant of the graphics space. Referring to Figure 2, the following factors are found to be the *critical factors* of high impact and low predictability.

- Working Parents
- Cost of living
- Desire for Leisure time
- Wish for good Quality of life
- Increasing necessary services

The major underlying factors influencing the *critical factors* are the skill level of women, work pressure and stress. Statistical data establish increasing participation of women in workforce [8], [9]. The cost of living is boosted by factors such as housing costs, energy costs, increasing necessary services. In Australia the average household energy consumption per person increased by 17 per cent between 1983-84 and 2003-04 [10]. Desire for more leisure time and better quality of life are other influential factors of high impact. The underlying influence behind these factors is the increased hours spent in

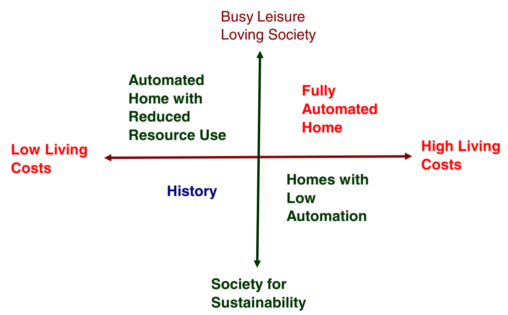

Fig. 3. Scenario Matrix

paid work. The average weekly hours worked for full-time and part-time workers have increased in Australia over the last two decades [10]. The above listed factors being of high impact, responsible for setting the trend these are called the *driving forces* for the present home lifestyle.

B. Three Scenarios

The driving forces are grouped into two trend setting factors of *busy leisure loving society* and *living costs*; these are taken as the dimensions of the scenarios. The horizon year is chosen as 2020. Contemplating positive and negative changes to the two factors in association with plausible variations to the underlying factors results in four scenarios.

The best case scenario is developed by allowing positive variation to one of the dimensions that is most desirable and negative variation to the other dimension. The most probable scenario is worked out by allowing variations to the chosen factors following the current trend as Variation Two leading to Scenario 2. The worst case Scenario is worked out that is extremely dissimilar to the current trend by allowing a substantial negative change to the most critical factor and contemplating changes to other factors in the positive direction. This is indicated by Variation Three resulting in Scenario Three. Scenario Four depicts the history where both factors have negative changes and that is not discussed in detail here. A scenario matrix as shown in Figure 3 is used to illustrate the four scenarios.

1) Scenario 1: Automated Home Supporting lower cost of living: In this scenario there is a division of trend. Following the current trend percentage of working women, work pressure and stress increases. The society is leisure loving and at the same time very concerned about the increasing cost of living. The major contributing factors are costs of housing and resources – power, gas, fuel, and water. Every effort is made to reduce the cost of living. As the population grows water becomes a scare resource and the price is increased. Many actions are taken to reduce the capital cost and running cost of maintaining houses. Average size of the house is reduced and houses are built to use natural sunlight and breeze effectively. Use of HVAC (Heating, Ventilation, Air Conditioning) systems are reduced. Each house has its own rain water tanks, grey water systems and water distribution systems. Electrical power production system is also built into the house. Home office is more formally established to reduce commuting to centrally located offices and thus counterfeit spending on fuel. Young mothers are given more flexibility in their working hours enabling them to facilitate early childhood education at home. This reduces expenditure on education and traveling costs. The above described lifestyle changes produce additional automation needs such as energy management, monitoring and distribution of water, monitoring and control of resource use.

2) Scenario 2: Leisure Loving Busy Families and Householders: In this scenario, by 2020 the percentage of working women has increased by 20 per cent globally resulting in more than 60 per cent dual income families. More than 40 per cent of the employed women has taken up skilled jobs demanding higher commitment. This became a necessity as the cost of living increased due to price hikes in housing, energy and water. The percentage of fully or partially employed people increased substantially due to the increase in retirement age also. These trends resulted in a society of people who are richer and busier. People are more stressed due to their full-time job in a highly dynamic environment.

Globalisation has resulted in more international business and increased travel by employees of corporate businesses. As women became more involved in corporate activities due to handling of executive positions, they needed to spend time to socialise with colleagues and business friends. Under these circumstances it became extremely difficult to look after household duties, being away from home more often, or mentally tired or busy. Generally women commenced job soon after their studies; taking up more interest in their career significantly reduced their expertise and enthusiasm in managing the household. Earning a good income and engaging in stressful job during the day prompted people to have more leisure time and improved quality of life. As women are well-employed, they play a major role in purchasing and facilitating households with modern amenities. As more and more women take up skilled and managerial jobs households need to be easily maintainable, cooking less tedious and time efficient, and also it should provide a relaxing environment. Better quality life style and leisurely activities become more prominent. Use of processed food is not considered as the best alternative to cooking for the generally health conscious society.

3) Scenario 3: Enlightened Hardworking Society Promoting Sustainability: The *driving forces* and related factors are influenced by other environmental elements such as government policies, economic changes, and social rules. Changing these factors impacts the lifestyle tremendously. The extreme modernisation and automation are found to be having an adverse effecting on the sustainability of the human population due to global warming and other environmental disasters. Governments and other social organisations started promoting more traditional way of life, consuming less industrialised products and resources. As a result of such drastic changes in policies world wide, an entirely different life style is followed by majority of people. Government policies promote mothers to stay at home and look after the children as many

TABLE II
USER CHARACTERISTICS AND OPERATIONAL CONSTRAINTS

User characteristic	value	Constraint
engagement	hectic or busy	Time
emotional state	stressed	attentiveness
physical state	tired	physical effort
skill Level	semi-skilled	operational skill
availability	rarely available	regular attention

TABLE III
PROCESS ATTRIBUTES AND OPERATIONAL REQUIREMENTS)

Process Attribute	value	Requirement
Ease of use	complex	skilled operator
Time requirement	time-consuming	Time
frequency of operation	routine	regular attention
operational effectiveness	erratic	attention
labour requirement	laborious	labour

social issues have been on the increase. People are strongly advised to use more fresh food rather than processed food. As the full-time housewife role re-appeared, growing vegetables, making snack food, and dress making became usual household activities.

In this new lifestyle some of the older traditions regained practice such as the use of more fresh food and home-made snack food. Households produced energy for its own use and also water collection and distribution became a household responsibility. This scenario depicts a lifestyle with an entirely different set of characteristics and thus automation needs. The women did more physical work and generally people felt more physically tired after mundane activities during the day. As people engaged in more labour involving work the average skill level reduced.

C. Automation Needs For a Society Following Scenario Two Lifestyle

The automation needs are worked out for the Scenario Two only as this is the most expected. It is quiet possible to modify the automation needs based on signals of deviation from the expected future.

Householders following this lifestyle generally exhibit the *User Characteristics* as shown in Table II. Main operational constraint mapping to each *User Characteristic* is also shown.

The *Process Attribute* values and corresponding operational requirement of the processes obtained from the analysis using Family System reference model is provided in Table III. A user constraint is a process requirement and hence these attributes become the Demanding Process Attributes. Using the analysis of Family system all processes with a matching Process Attribute value to one or more of the *Process Attributes* listed in the table above are selected.

TABLE IV
PROCESSES HAVING DEMANDING PROCESS ATTRIBUTE(DPA)

Process Name	DPA
Schedule Meals for a Week	routine; time consuming
Select Menu and Recipes	routine; time consuming
Prepare grocery List	routine; time consuming
Update Stock	routine
Prepare items for cooking	routine; time consuming
Cook	routine; time consuming
Clean utensils and kitchen	routine; time consuming
Budgeting	complex
Account Keeping	routine
Financial Planning	complex
Schedule Payment	routine; complex
Monitor and Control Expenses	routine; complex
Monitor diet	routine
Monitor Health Parameters	routine
Monitor Exercise	routine
Schedule School Events	routine
Monitor Study Progress	routine; complex
Update Equipment Inventory	complex
Manage Equipment services	erratic
Manage service providers	routine

VI. CONCLUSION

The new method of REFUSS presented here provides a systematic, simple and applicable method for future user requirement elicitation. A formal method for identification of user characteristics based on future lifestyle scenarios that are dependent on environmental factors can be used for any futuristic studies. The systematic correlation of process knowledge with user characteristics can have applications in any system requirement analysis involving technology applications. The REFUSS integrates scenario technique with technology roadmapping thus enabling formulation of futuristic vision with re-assessment provision for strategic planning.

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