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Maturity Assessment Framework for Business Dimension of Software Product Family

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Abstract: The software product family approach aims at curtailing the concept of "reinventing the wheel" in the software development process. The business has been highlighted as one of the critical dimensions in the process of software product family. This work presents an assessment framework for evaluating the business dimension of software product family process. Additionally, a software product family business evaluation tool has been designed and implemented on the basis of the presented framework. The tool preprocesses the data of key business factors, and it evaluates the overall business maturity of an organization. To demonstrate the application of the framework, and to determine the current software product family business performance, we conducted a case study of an organization actively involved in the business of software product family. The framework and the tool provide direct mechanisms to evaluate the current maturity level of software product family business of an organization. This research is a contribution towards establishing a comprehensive and unified strategy for a process evaluation of the software product family.

Introduction

The software product family has become one of the most promising practices with the potential to substantially increase the productivity of software development process. It has emerged as an attractive phenomenon within organizations dealing with software development. Software product family is a collection of software systems built from a common underlying architecture and a set of software assets in order to address the needs of a particular market segment. There are other corresponding terminologies for software product family, ones, which have been widely used in Europe and North America: for example, "product population", "system families", and "software product line". Ommering [1] introduced the term "product population", which is a collection of related systems based on similar technology but having many differences among them. The software product line is a comprehensive model for an organization building applications that are based on a common architecture and core assets [2]. Clements [3] defines the term "software product line" as a set of software systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment, and that are developed from a common set of core assets in a prescribed way. The economic potentials of software product line have long been recognized in the software industry [4][5]. Clement *et al*. [6] reported that software product line engineering is a growing software engineering sub-discipline, and many organizations, including Philips, Hewlett-Packard, Nokia, Raytheon, and Cummins, are using it to achieve extraordinary gains in productivity, time to market, and product quality.

In today's digitized economy, every organization strives to capture a major portion of the market segment in order to sustain profitable business. Many global organizations dealing in wide areas of operations such as consumer electronics, telecommunication, avionics, and information technology, perceive the software product family as being the future of software development in order to achieve cost reduction, short development time, and improved quality. The business of the software product family requires improvements over time in order to maintain an advantage over competitors. It is very difficult to organize an efficient and effective improvement plan unless it is based on the results of a comprehensive assessment exercise. Business assessment determines the current status of the business maturity of an organization, and it identifies the areas that need improvements. This work presents the business maturity assessment framework for the organizations dealing with software product family practice.

Related Work: Process Maturity Evaluation of Software Product Family

Software product family process assessment is a relatively a new area of research where not much work has been done. Currently, researchers from both academe and industry are working to develop a prescribed and systematic way of measuring the maturity of a software product family process. Jones and Soule [7] discuss the relationships between software product line process and the Capability Maturity Model Integration (CMMI). They observe that the software engineering process areas specified in CMMI provide an important foundation for software product line practice. They compare the software engineering process areas of the software product line and CMMI and find some similarities, but conclude that there is still a need to establish a comprehensive strategy for process assessment of the software product line. The Software Engineering Institute (SEI) proposed the Product Line Technical Probe (PLTP)[8]. The objective of PLTP is to discover the ability of an organization to adapt and succeed with the software product line approach. PLTP is based on the framework for software product line practice proposed at SEI, and it divides the overall engineering activities of software product line engineering into a set of three categories: product development, core assets development and management. However, PLTP does not set forth any methodology to evaluate the maturity of the software product line process.

Ahmed and Capretz [9] propose a set of rules for developing and managing a software product line within an organization. On the basis of the proposed rules, a fuzzy logic-based software product line process assessment tool was designed and implemented. The tool provides an opportunity to evaluate the maturity of the software product line process within an organization. A number of case studies were conducted on the industrial software process data from reputable software development organizations. The results of the study were compared with the existing CMMI levels of the organizations in order to compare the assessment produced by two different approaches. One of the conclusions of their work also suggests that there is still a need to establish a unified and comprehensive strategy for process assessment of the software product line.

In Europe, the acronym BAPO [5] (Business-Architecture-Process-Organization) is very popular for defining process concerns associated with software product family, as illustrated in Figure 1. The "Business" in BAPO is considered critical because it deals with the way the products resulting from software product family make profits. *van der* Linden *et al*. [10] propose a four dimensional software product family maturity evaluation framework primarily based on the BAPO concept of operations. This provides an early foundation for a systematic and a comprehensive strategy for process maturity evaluation of software product family. Figure 2 illustrates the conceptual layout of this approach. The four dimensions of the framework are: business, architecture, process and organization. *van der* Linden *et al*. [10] identifies maturity scales of up to five levels in ascending order for each dimension of BAPO, as illustrated in Table-1. In the case of software product family, this results in separate values for each of the four dimensions. However, the conceptual model of software product family maturity evaluation, shown in Figure 2 does not address a number of key steps involved (shown with dashed rectangles) including:

- The definition of maturity scale for overall software product family process.
- The frameworks to evaluate the four dimensions of business, architecture, process, and organization.
- The methodology to evaluate the overall maturity profile of an organization once the assessment results of individual dimensions, such as business, architecture, process and organization, have been obtained. The circle with cross (in Figure 1) represents this stage.

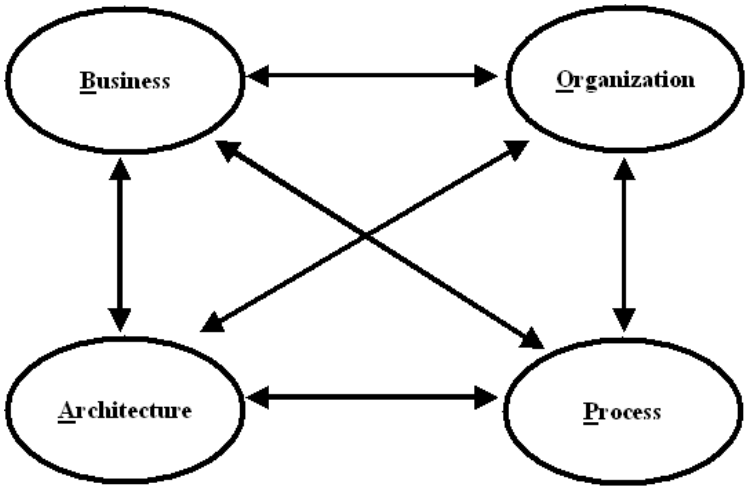

Figure 1: Business- Architecture- Process- Organization Concept of Operations of Software Product Family

The main contribution of the research presented in this paper is to put forward a maturity assessment framework for measuring the business dimension of software product family, where no work has been done yet to the best of our knowledge. The gray shaded rectangle in Figure 1 clearly highlights the scope of this work within the conceptual layout of software product family maturity assessment. This work is one of the steps in the BAPO-based framework of software product family

maturity assessment. This research contributes towards establishing a comprehensive and unified strategy for process maturity assessment of software product family.

	Business	Architecture
Level 1	Reactive	Independent Product Development
Level 2	Awareness	Standardized Infrastructure
Level 3	Extrapolate	Software Platform
Level 4	Proactive	Software Product Family
Level 5	Strategic	Configurable Product Base
	Process	Organization
Level 1	Initial	Unit Oriented
Level 2	Managed	Business Lines Oriented
Level 3	Defined	Business Group/Division
Level 4	Quantitatively Managed	Inter Division/Companies
Level 5	Optimizing	Open Business

Table 1: Maturity Levels of Four Dimensions in BAPO Model

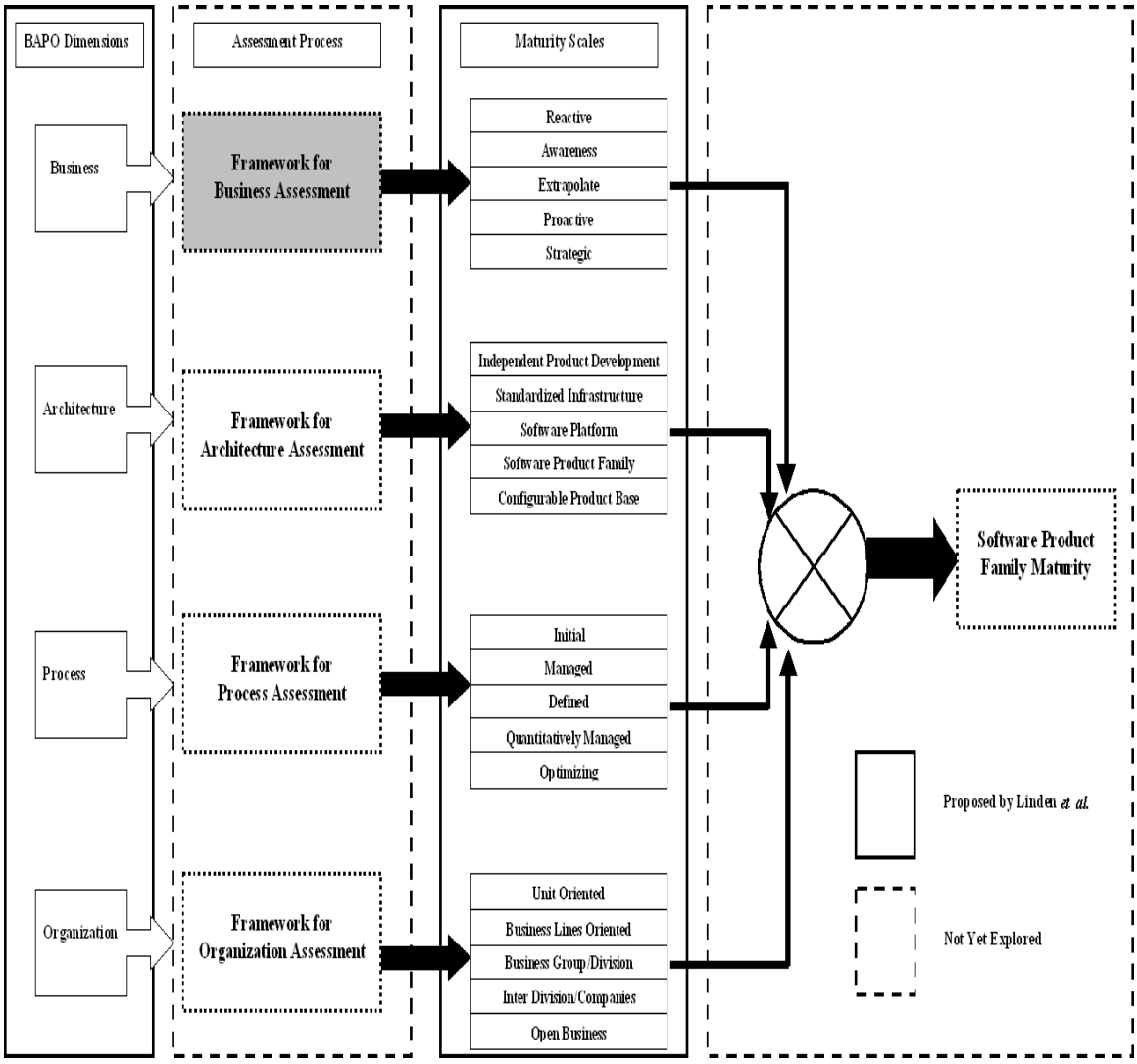

Figure 2: Software Product Family Process Maturity Assessment Approach

Related Work: Software Product Family and Business Dimension

At Fraunhofer Institute of Experimental Software Engineering (IESE) Bayer *et.al* [11] develop a methodology for the purpose of enabling the conception and deployment of software product family within a large variety of enterprise contexts, called PuLSE (Product Line Software Engineering). PuLSE-Eco is a part of PuLSE methodology that deals with defining the scope of software product family in terms of business factors. PuLSE-Eco identifies various activities that directly address the business needs of software product family, needs such as system information, stakeholder information, business objectives and benefit analysis. *van der* Linden *et al*. [10] identify some main factors in evaluating the business dimension of software product family, factors such as identity, vision, objectives, and strategic planning. Clements and Northrop [8] highlight customer interface management, market analysis, funding, and business case engineering as important activities from the perspectives of organizational management. Kang *et al*. [12] present a marketing plan for software product family that includes market analysis and marketing strategy. The market analysis covers need analysis, user profiling, business opportunity, time to market and product pricing. The marketing strategy discusses product delivery methods. Toft *et al*. [13] propose "Owen molecule model" which consists of three dimensions: social, technology and business. The business dimension deals with setting up business goals and analyzing commercial environment. Fritsch and Hahn [14] introduce Product Line Potential Analysis (PLPA) which aims at examining the product line potential of a business unit through discussions with managers of the business unit because, in their opinion, business managers know the market requirements, product information, and business goals of the organization. Schmid and Verlage [15] discuss the successful case study of setting up software product family at Market Maker, and they highlight some significantly important activities such as market and competitor analysis, and a vision of potential market segment and products from business aspects of software product family process. Ebert and Smouts [16] weight marketing as one of the major external success factors of product line approach and further conclude that forecasting, the ways to influence market, a strong coordination between marketing and engineering activities are required for gaining benefits from product line approach. The summary of the related work presented in this sub-section highlights some key business factors such as strategic planning, innovation, market orientation, business vision, order of entry, and customer orientation. We used these key business factors as the basis of the framework presented in this paper to evaluate the business maturity of software product family of an organization.

The Business Dimension of Software Product Family

Business is perhaps the most crucial dimension in the software product family process, mainly due to the necessities of long-term strategic planning, initial investment, longer payback period, and retention of the market presence. Business assessment is an essential activity for improving the overall software product family process because it provides in-depth information about the status of the

business. The business requires improvements over time, mainly due to external and internal forces of change. It is very difficult to develop an efficient and effective improvement plan unless it is based on the results of a comprehensive assessment exercise. Business assessment determines the current status of the business performance of an organization and identifies the areas that require improvement. A comprehensive methodology is proposed in this paper for the business assessment of organizations dealing with software product family. The business process consists of certain set of activities to cover various aspects of the business. In this paper we termed those sets of activities as "key business factors", and used them to evaluate the business maturity of an organization. These key factors, which constitute the overall business strategy and the operations of the organization, largely determine the success or failure of the business endeavors of an organization. The key business factors used in this framework are market orientation, strategic planning, order of entry, brand name strategy, innovation, relationships management, assets management, business vision and financial management. The choice of using these key business factors in this study in order to evaluate the business maturity of an organization is based on the literature survey of research in software engineering, software product family, business, organization and technical management. Short descriptions of these key business factors, along with their aspects related to software product family, are provided in the next sub-sections.

Market Orientation

Market orientation deals with the acquisition, sharing, interpretation and utilization of information about customers and competitors. According to Kohli and Jaworski [17] in market orientation the organization collects market intelligence about the current and future needs of customers, and, disseminates this intelligence across various entities within an organization for decision-making purpose. The software product family deals with developing a considerable number of products to capture a share in the market. Market orientation provides essential information about the concerns and requirements of customers, information which needs to be accommodated in the successive products from a product line. Customer orientation enables an organization to develop customer-centered products. This information assists in the domain and application engineering activities of the software product family process. Information regarding the competitors is used to exploit product functionalities in order to attract new customers. The orientation of customers and competitors determines the schedules for the delivery of software products into the market at an appropriate time. Table 2 illustrates the market orientation assessment questions that are part of the software product family business assessment framework. They are designed to receive feedback from organizations in order to evaluate how effective is their market orientation.

Relationships Management

Wilson [18] observes that relationships management is concerned with the development and maintenance of close, long-term, and mutually beneficial and

satisfying relationships between individuals or organizations. Crosby *et al*. [19] considers relationships management as the extent to which parties have the orientation or behavioral tendency to actively cultivate and maintain close working relationships. Relationships management plays a significant role in successful software product family business. Software products generally require assistance from the seller to successfully install and train the customers so that they can use the product effectively. An excellent customer support service enhances the satisfaction of the customers with the product. Customer profiling suggests new features in successive products from the software product family. Promotional strategies like incentives in purchasing new products further increase the sales and provide the justification of the product family infrastructure. Table 3 illustrates assessment questions of relationships management that are part of the software product family business assessment framework. This assessment questionnaire is designed to measure the effectiveness of the relationships management of an organization.

1	Does the organization use feedback from customers to improve the quality of products and services?
2	Does the organization use feedback from customers to develop new products or services?
3	Does the organization have adequate knowledge about its customers and competitors?
4	In making decisions about new products, does the organization give consideration to the complaints and issues of its customers?
5	Does the organization have adequate resources and skills to gather information about the market?
6	Has the organization established a defined inter-communication protocol among external and internal entities for the dissemination of market intelligence?
7	Does the organization successfully respond to the actions of competitors and is it able to decrease the number of competitors over a period of time?
8	Does the organization regularly collect and analyze data from the consumer market to identify opportunities for new market segments?
9	While engaging in strategic market planning, does the organization explicitly consider competitors as its top priority?
10	Is the organization able to increase its targeted market size over time?

Table 2: Market Orientation Assessment Questionnaire

1	Does the organization have fast and accurate means to access the required information in order to facilitate responses to the queries of customers about different products and services?
2	Does the organization have a well-established system to quickly extract, manipulate and produce data for profitability analysis, customer profiling, and retention modeling?
3	Does the organization attract new and existing customers through personalized communication and innovative targeting methods?
4	Does the organization have an established promotions strategy to attract new customers and retain existing ones?
5	Does the organization simplify its business processes regularly in order to enhance the experience and satisfaction of customers?
6	Is the organization able to retain its customers over a long period of time?
7	Do the competitors perceive the software product family of the organization as a direct threat to their business?
8	Is the software product family able to respond quickly to actions of the competitors?
9	Regarding customers and competitors, has the organization established efficient resources for market intelligence?
10	Has the organization established a balance in customer and product-centered approaches in product development?

Table 3: Relationships Management Assessment Questionnaire

Order of Entry

There are three observable categories in a firm's order of entry in the market: pioneers, early followers, and late movers [20] [21]. The benefits of being the first in the market have long been recognized in the business sector. The pioneers can gain a sustainable competitive advantage over followers because, initially, they are the only solution providers in the market. The appropriate timing of technology-based products to enter into the market is critical in capturing big share in market. The timing to launch a software product into the market is even more essential for software development organizations. The software product family produces successive products having controlled variability and commonality. The new products from the software product family share a common architecture and essentially have features common to their predecessors. In order to capture major shares of the market, timing is essential in launching a new product from the software product family. The order of entry into the market depicts the delivery schedule for the software product family and provides guidelines to the developers about development schedules. Table 4 illustrates order of entry assessment questions that are part of the software product family business assessment framework.

1	Do the products developed from the software product family enter into the market at the appropriate time?
2	Does the organization have the potential of being first in the market?
3	Is the organization regarded as a pioneer in product development or is it perceived as follower?
4	Does the software product family allow the organization to take advantage of being first in the market?
5	Do the products that develop from software product family are in response to actions of competitors?
6	Is the software product family able to increase the market presence of the organization?
7	Do the successive products of the software product family help in retaining current customers and have the tendency to attract new customers?
8	Is the software product family able to meet the demands of the delivery schedule of the customers?
9	Does the organization regularly conduct market reviews and update the development and delivery schedule of the software product family, keeping in view the market trends and needs?
10	Are the customers satisfied with the timing of a new product launch?

Table 4: Order of Entry Assessment Questionnaire

Brand Name Strategy

Organizations consider brand name as a crucial catalyst of business success. A brand is regarded as both a promise of quality to customers and a point of comparison with other products or services. Bennett [22] defines brand as a name, term, sign, symbol, design, or any combination of these concepts, used to identify the goods and services of a seller. Brand name products generally have a higher potential in increasing the business of an organization. Bergstrom [23] observes that in the proliferation of competitors and products that are easily duplicated or replaceable, brands become an important means of simplifying the decision-making process for buyers or users. Software product family business is even more inclined towards a brand name strategy, because it envisages the business growing with a

stream of products having commonality and variability among them. The brand name strategy in the software product family has a twofold advantages. First, it expands the market for profitable business, and, secondly it acts as a guide for new business cases, which serve as an extension of current products. Table 5 illustrates brand name strategy assessment questions that are part of the software product family business assessment framework and are designed to get feedback from organizations in order to evaluate how effective is the brand name strategy of the organization.

1	Is the organization involved in a direct or indirect brand name strategy of the software product family?
2	How is the software product family of the organization unique or different from the products of other competitors?
3	Are the new products from the software product family consistent with the current brand extension?
4	Does the organization continuously monitor the performance of the brand in the market?
5	Is the brand of software product family aligned with the strategic plans of the organization?
6	Are the new products from the software product family attracting the customers, and are they considered as an extension or even an improved version of the predecessor?
7	How important does the organization considers brand name strategy for the software product family?
8	Does the business vision of the organization foresee a brand name for the software product family?
9	Is the software product family in direct one-to-one competition with the competitors in the market?
10	Are the decisions of the customers influenced by the brand name of the software product family?

Table 5: Brand Name Strategy Assessment Questionnaire

1	Does the organization have a well-documented business vision statement?
2	Is the business vision of the organization communicated within to all members of the organization?
3	Does the business vision statement clearly state where the organization is going in the future?
4	Is the software product family a part of the business vision of the organization?
5	Is the business vision statement regularly reviewed, and updated?
6	Do the employees understand the importance of the software product family in the business vision and feel that the organization can realistically achieve its targets?
7	Does the software product family play a significant role in the business vision of the organization?
8	Is the software product family development essential for the organization to reach future goals?
9	Does the business vision of the software product family aim at retaining current customers and attracting future ones?
10	Does the software product family play a major role in achieving future financial goals?

Table 6: Business Vision Assessment Questionnaire

Business Vision

In practice, business vision is a statement that is prepared by top management and communicated to all members of the organization. The statement includes the identification of a desired future, and a well-established connection between the future and the present state. A successful business vision plan requires all the

employees within the organization to participate and to clearly understand the vision statement. The business vision describes the commitment of the organization achieving a goal. The software product family plays a significant role in the business vision because it tends to produce long-term benefits to the organization. The software product family is a part of strategic assets of an organization, which can be mobilized to establish a connection between the present and future goals. The importance of the software product family in an organization requires answering two questions: how the organization fits the software product family in the business vision and also, how important the software product family is in its' future plans. Table 6 illustrates business vision assessment questions that are part of the software product family business assessment framework. This assessment is designed to receive feedback from organizations in order to evaluate the importance of software product family in business vision of an organization.

1	Does the organizational strategic planning give the software product family as an important consideration?
2	Is the software product family aligned with the strategic plans of the organization?
3	Does the strategic planning allocate sufficient resources for software product family development?
4	Do the strategic plans highlight an evolution in the software product family under changing business conditions?
5	Does the software product family play a significant role in achieving the strategic objectives of the organization?
6	Do the strategic plans define how an organization will achieve the technological capability to successfully adopt the concept of the software product family development?
7	Does the strategic planning identify key market segments for the software product family business?
8	Does the management have strategic plans about the order of entry of software products into the market?
9	Do the strategic plans envision new products from the software product family?
10	Do the strategic plans create a roadmap aligned with the business vision of the organization?

Table 7: Strategic Planning Assessment Questionnaire

Strategic Planning

A strategic plan of an organization specifies a set of activities performed to accomplish the desired level of achievement in a particular area. Strategic planning starts with elaborating strategic objectives. Harrison [24] asserts that objectives indicate what management expects to accomplish, whereas planning sets forth how, when, where and by whom the objectives will be attained. Strategic planning is a continuous process within an organization. It determines business goals, evaluates the obstacles, and defines approaches to deal with those obstacles. It outlines definite tasks for individuals, groups, and for the entire organization, tasks which are needed to accomplish these goals. In order to set clear objectives, and align organizational resources to match opportunities and counter threats, software product family development requires consideration in the strategic planning of the organization. The future directions of the business must accommodate the software product family as an integral asset. The software product family process needs resources that must be delegated in strategic plans. In order to gain competitive advantages, capture market segments, and achieve strategic targets, strategic planning must clearly outline what is to be developed from the software product family. This planning ensures that decisions made to

allocate and commit resources reflect the relative significance of the software product family in achieving the long-range business goals. Table 7 illustrates strategic planning assessment questions that are included as part of software product family business assessment framework. This questionnaire is designed to get information about the maturity of the strategic planning of an organization dealing with software product family.

Assets Management

Assets management outlines action plans for the creation, acquisition, maintenance, replacement and disposal of assets to provide an agreed-upon level of cost-effective and sustainable development. The assets management has a direct impact on the performance and success of the business. Chen [25] concludes that assets management of computing resources is a process that helps in managing hardware/software procurement, usage, and update and it tracks inventory, enables change, and improves overall efficiency in software development. The notion of the software product family is conceptually aligned with assets management. The software assets repository establishes a production capability for the software product family. A strategic goal of assets management in the software product family is the optimal use of computing resources during product development. Assets management for the software product family process provides a way of managing the infrastructure, and understanding the production needs of the software development. The observable fact of reusability in the software product family development process advocates that software assets management gain benefits while developing a family of similar products. The questionnaire shown in Table 8 illustrates assets management assessment questions. They are part of the software product family business assessment framework.

1	Does the organization have a defined policy of managing assets for the software product family?
2	Is the information about core assets well communicated to all personnel involved in development related activities?
3	Are the assets of the software product family dynamic, and do they continuously grow as the production proceeds?
4	Are all the assets in the repository consistent with the scope of the software product family?
5	Does the organization maintain information about assets, as well as versions and utilization history during product development?
6	Is the assets management of the organization aligned with the strategic planning?
7	Have the software assets significantly reduced the development cycle of the software product family?
8	Are the software assets consistent with the production constraints and the production plan of the software product family?
9	Does the software assets management activity satisfy the cost-to-benefits ratio for the organization?
10	Has the organization allocated sufficient resources for managing software assets?

Table 8: Assets Management Assessment Questionnaire

Innovation

One of the keys to a successful business in today's competitive environment is innovation. Organizations are continuously adopting innovations in major areas of business operations such as technology, administration and production process. Innovation is regarded as a by-product of research and development. Martensen and Dahlgaard [26] conclude that innovation should be closely linked to the vision of the company and its overall business strategy. Innovation and continuous improvements in processes and products illustrate the capability of the organization to be creative and to be pioneers in product development. The success of the software product family is largely dependent on innovative ways of identifying potential business cases. Business cases that offer additional features with innovative ideas embedded in them have a greater potential of success in capturing the attention of new and existing customers. Software product family development not only requires research and development to enhance the process methodology and the industrialization of this concept, but it also needs innovative measures for selecting, developing and launching business cases. New ideas in market orientation and in relationships management are the true goals of the software product family in capturing a major market share. The questionnaire shown in Table 9 illustrates innovation assessment questions that form part of the software product family business assessment framework.

1	Has the organization defined a road map for research and development in software product family?
2	Does the organization successfully employ innovations in the software product family development?
3	Does the organizational culture support innovation in the software product family?
4	Does the organization use any specific guidelines or process model that represent the macro elements of the software product family innovation process?
5	Do the employees have opportunities to participate in problem solving and idea generation activities for the software product family?
6	Are the innovations in the software product family aligned with the existing business goals?
7	Does the management support reactive and proactive innovations in the software product family process?
8	Does the organization allocate sufficient resources to research and development in the software product family?
9	Does the organization's past research improve the development and management processes of the software product family?
10	Does the organization believe that investment in R&D can yield positive results in the near future?

Table 9: Innovation Assessment Questionnaire

Financial Management

Financial management deals with making decisions about fiscal matters within an organization. A financially strong organization envisions business progress, especially in terms of income, balance, and cash flow. Effective financial policies lead to successful businesses. The financial strength of an organization has a major impact on software product family development and management. Some of the financial indicators generally used in monitoring the performance of the business, found in [27] are as follows:

- **Current Ratio:** is the ratio between all current assets and all current liabilities, i.e. $\frac{Current\_Assets}{Current\_Liabilities}$; a ratio of more than 1 is in favorable in an organization.
- **Debt to Equity:** shows the ratio between capital invested by the organization and the funds provided by lenders, i.e. $\frac{Debt}{Equity}$; a lower value shows the financial strength of an organization.
- **Debt Coverage Ratio:** indicates how well cash flow covers debt and the capacity of the business to acquire additional debt, i.e. $\frac{Net\_Profit + Expenses}{Total\_Debt}$; a higher value indicates organization is earning well and can pay back its liabilities.

- **Sales Growth:** a percentage increase (or decrease) in sales between two time periods, i.e. $\frac{Current\_Year\_Sale - Last\_Year\_Sale}{Last\_Year\_Sale}$ X 100; a higher value shows a growth in sales.
- **Net Profit Margin:** indicates how much profit comes from sales, i.e. $\frac{Net\_Profit}{Total\_Sale}$; an improvement in this ratio shows how effectively an organization is growing its' sale.

- **Return on Assets:** is a measure of how effectively assets are used to generate a return, i.e. $\frac{Net\_Profit}{Total\_Assets}$; a higher value indicates assets are being used effectively for return.

- **Return on Investment:** is a measure of net benefits from a given investment, i.e. $\frac{Net\_Profit}{Total\_Investment}$; a higher value shows the financial strength of organization.

- **Payback Period:** is the number of years required for covering the cost of an investment, i.e. $\frac{Total\_Investment}{Periodic\_Savings}$; a lower value depicts the ability of an organization to cover the market.

Financial management revolves around the software product family. A successful software product family plays a key role in achieving the desired financial strength of an organization. Some of the financial indicators, such as current ratio, debt to equity and debt coverage ratio, highlight an organization's ability to invest in the software product family. Sales growth and net profit margin depict how successfully the software product family contributes to business growth. Return on assets, return on investment and pay back period indicate the potential of the

software product family to achieve the long-term financial goals of an organization. The questionnaire shown in Table 10 illustrates financial management assessment questions, and form a part of the software product family business assessment framework.

1	Is the current ratio of total assets and current liabilities higher than one?
2	Is the ratio of total debt to total capital decreasing over a period of time?
3	Is the organization able to reduce its debt?
4	Do the sales grow over a period of time?
5	Does the net profit margin increase over a period of time?
6	Does the return on assets increase over a period of time?
7	Does the return on investment increase over a period of time?
8	Does the payback period decrease over a period of time?
9	Does the software product family fit into the financial model of the organization?
10	Is the software product family contributing towards strengthening the financial position of the organization?

Table 10: Financial Management Assessment Questionnaire

Software Product Family Business Evaluation Tool (SPFBET)

The business assessment of software product family of an organization requires input from the organization about the status of various activities that contribute in the performance of overall business process. The questionnaires presented in Tables 2, 3, 4, 5, 6, 7, 8, 9, and 10 serve as an initial source of contact to receive feedback from an organization. There are 10 questions for each key business factors, 90 questions altogether. A fuzzy logic-based tool was designed and implemented on the basis of questionnaires shown in Tables 2 to 10. This tool was intended to measure the business performance of an organization by processing the data of key business factors. It is important to mention here that a detailed discussion of the fuzzy logic approach and its methodology is beyond the scope of this paper. The overall processing sequence of the tool, shown in Figure 3, illustrates that:

- The assessment of individual key business factors such as market orientation, relationships management, and order of entry are measured by using the respective questionnaires as an input to a fuzzy logic system.

- Overall business performance is evaluated by applying the assessment of individual key business factors to the next stage fuzzy logic system.

Fuzzy logic system [28] [29] requires certain inputs to process. In fuzzy logic system, the term "crisp value" is used to represent any precise numerical value such as 2, –3, or 7.34. In order to take inputs in the form of crisp values, questionnaires shown in Tables 2 to 10 are used. The crisp input to the fuzzy logic system depends on the values entered for each question. In order to measure the extent to which each of the questions in the questionnaires about key business factors was practiced in the organization; we used multi-item, five-point Likert scales that ranged from "Strongly Disagree" (1) to "Strongly Agree" (5). Figure 4 illustrates a two-variable fuzzy logic system used for processing of key business factors data. The system requires the input of two variables, which can be any

combination of two questions presented in Tables 2 to 10. These two variables perform a fuzzification process which converts the crisp input into a fuzzy membership mapping that is applied to the inference engine, which in turn interacts with rule base to select the applicable rules based on the input variable values. The fuzzy output is then defuzzified to retrieve a crisp output. The design decision of two variable approach of fuzzy logic is based on an associative property of fuzzy sets. Since the questions presented in Tables 2 to 10 can be further increased to accommodate other possible aspects of the software product family, this design choice can therefore easily accommodate further expansion of input to the system.

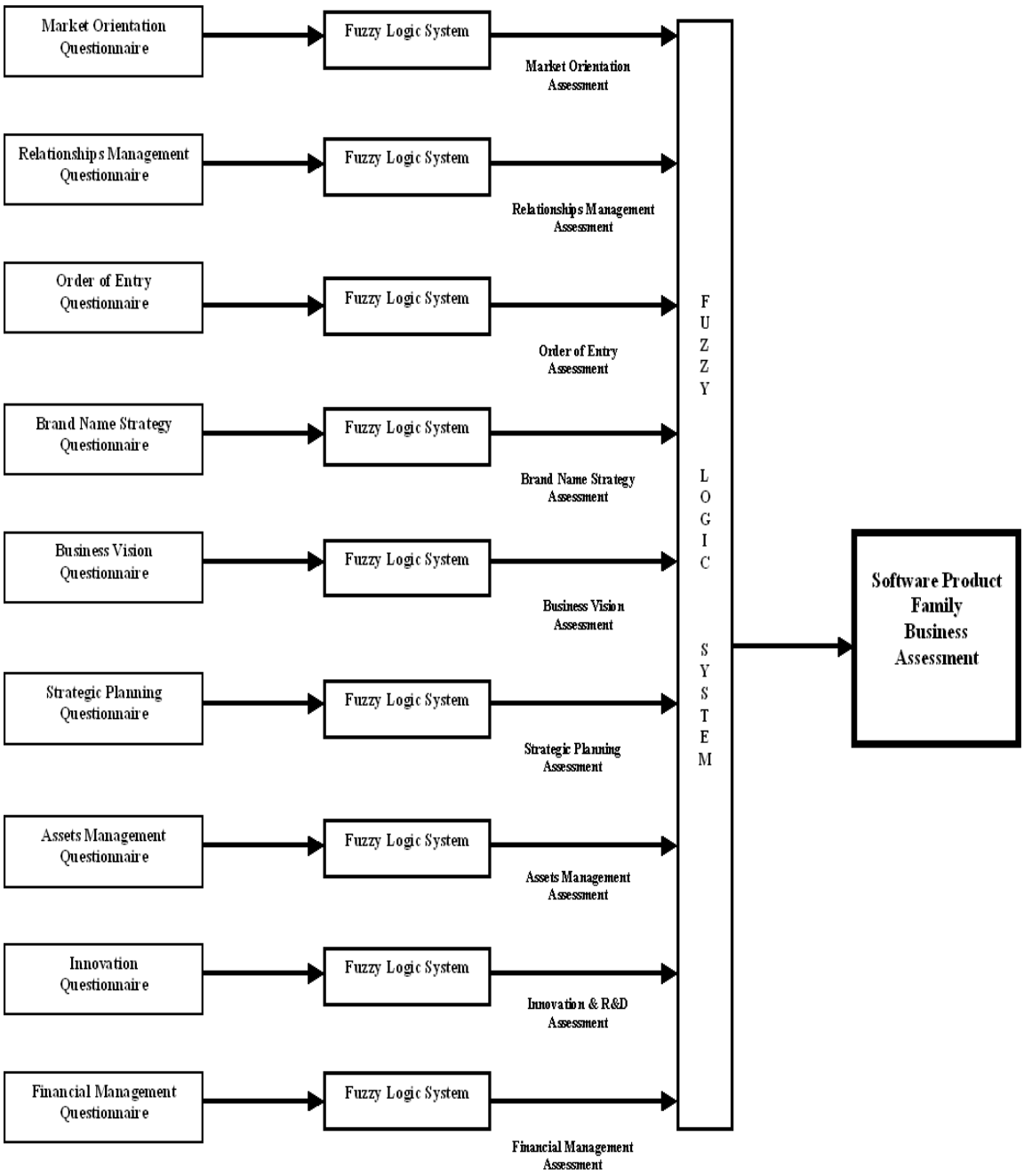

Figure 3: Processing Sequence of SPFBET

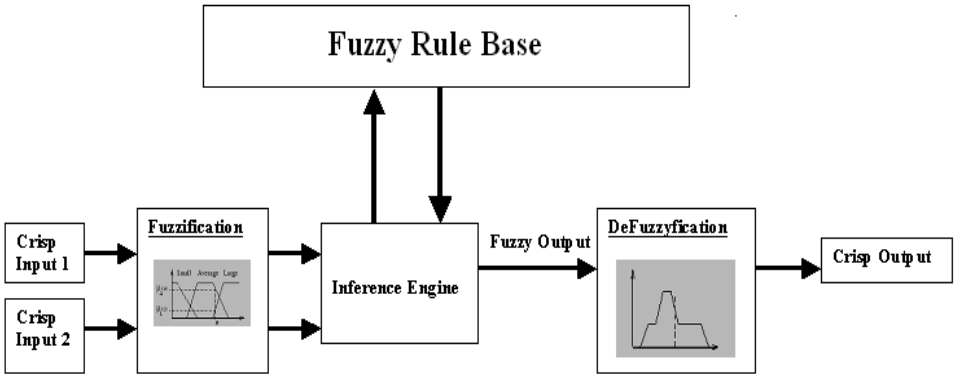

Figure 4: Two-Variable Fuzzy Logic System Architecture

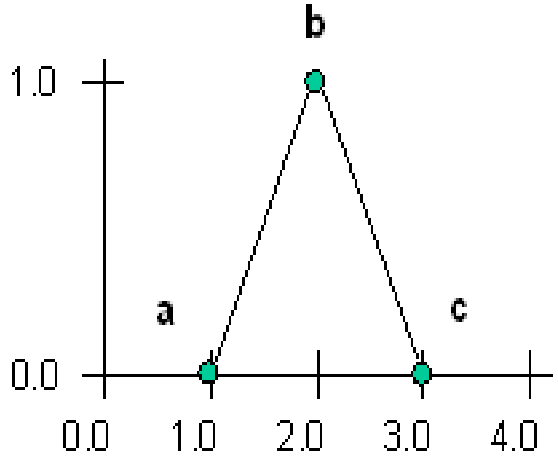

Figure 5: Triangular Fuzzy Set

$$f(x;a,b,c)=\begin{cases}0, & x\le a\\ \dfrac{x-a}{b-a}, & a\le x\le b\\ \dfrac{c-x}{c-b}, & b\le x\le c\\ 0, & c\le x\end{cases}$$

Figure 6: Triangular Model

The crisp input and output to the system is selected to fall in the range of 1 to 5. The crisp input values are divided into five linguistic variables: "Strongly disagree", "Disagree", "Neither agree nor disagree", "Agree" and "Strongly Agree". The crisp output values are divided into five linguistic variables: "Reactive", "Awareness", "Extrapolate", "Proactive" and "Strategic". They are the same maturity scales for business dimension that are put forward by van der Linden et al. [10]. The input and output variables are represented by a triangular function. The graphical representation and mathematical equation of triangular functions used to portray the linguistic variable of the input and output are shown in Figures 5 and 6. The triangular function retains the highest fuzzy membership value of "1" at a certain required point. The variables "a", "b", and "c" construct the shape of the triangle. The variables "a" and "c" represent the lower right and left points of the triangle where the fuzzy membership mapping is minimum of 0, whereas the variable "b" illustrates the highest fuzzy membership mapping of 1. The choice of variables a, b, and c to represent the triangular function for all five linguistic variables of input and output is illustrated in Table 11.

The fuzzy logic rule base is created to contain fuzzy logic rules for fuzzy reasoning, particularly for the software product family business evaluation tool, by having discussions with experts in the various organizations actively involved in software product family business. The rules define combinations of the crisp inputs pattern and the respective output. On the basis of the inputs, appropriate output mapping

is defined in the fuzzy logic rules. The variables defined as input_1 and input_2 can be any combination of questions presented in the questionnaires. There are fifteen rules for the software product family business evaluation tool. Table 12 shows the truth table of the fuzzy rule base.

Input Linguistic Variable	Output Linguistic Variable	Crisp Value Range	Triangular Function Variable Values For Fuzzy Membership Mapping		
			a	b	c
Strongly disagree	Reactive	1 to 2	1	1	2
Disagree	Awareness	1 to 3	1	2	3
Neither agree nor disagree	Extrapolate	2 to 4	2	3	4
Agree	Proactive	3 to 5	3	4	5
Strongly agree	Strategic	4 to 5	4	5	5

Table 11: Input (Likert Scale) and Output Linguistic Variables And Fuzzy Membership Mapping

S.No	Input_1	Input_2	Output
1	Strongly disagree	Strongly disagree	Reactive
2	Strongly disagree	Disagree	Awareness
3	Strongly disagree	Neither agree nor disagree	Awareness
4	Strongly disagree	Agree	Extrapolate
5	Strongly disagree	Strongly agree	Extrapolate
6	Disagree	Disagree	Awareness
7	Disagree	Neither agree nor disagree	Extrapolate
8	Disagree	Agree	Extrapolate
9	Disagree	Strongly agree	Extrapolate
10	Neither agree nor disagree	Neither agree nor disagree	Extrapolate
11	Neither agree nor disagree	Agree	Proactive
12	Neither agree nor disagree	Strongly agree	Proactive
13	Agree	Agree	Proactive
14	Agree	Strongly agree	Strategic
15	Strongly agree	Strongly agree	Strategic

Table 12: Truth Table of Fuzzy Rule Base

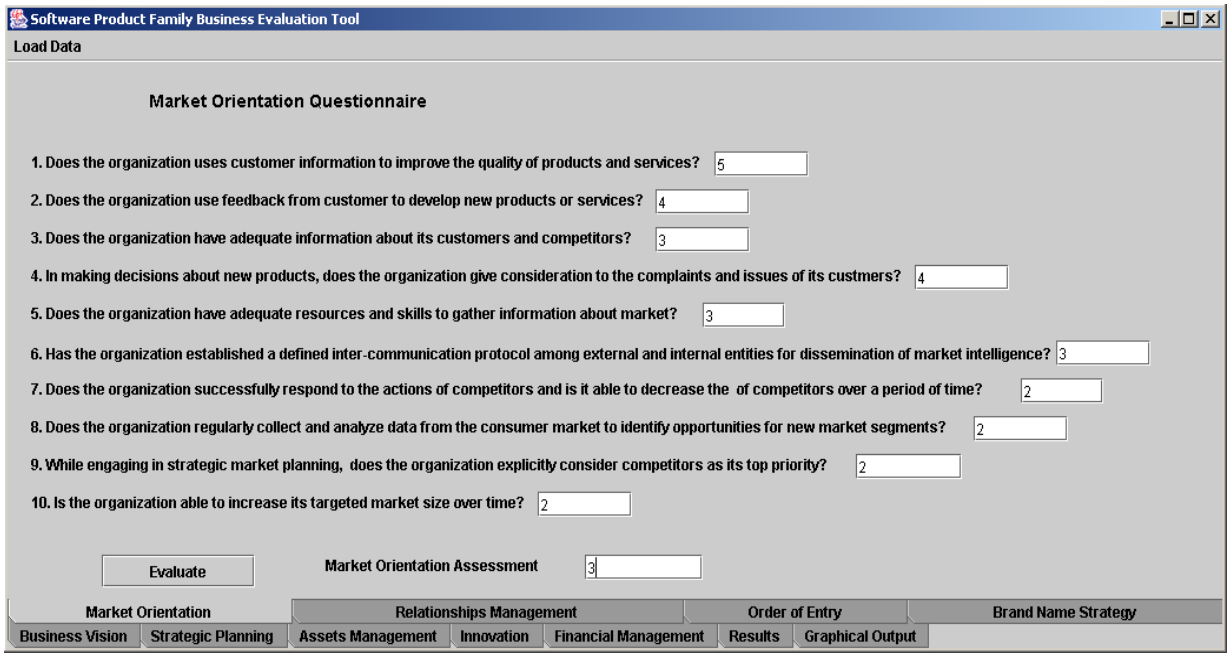

Figure 7: Input Screen Shot of Software Product Family Business Evaluation Tool

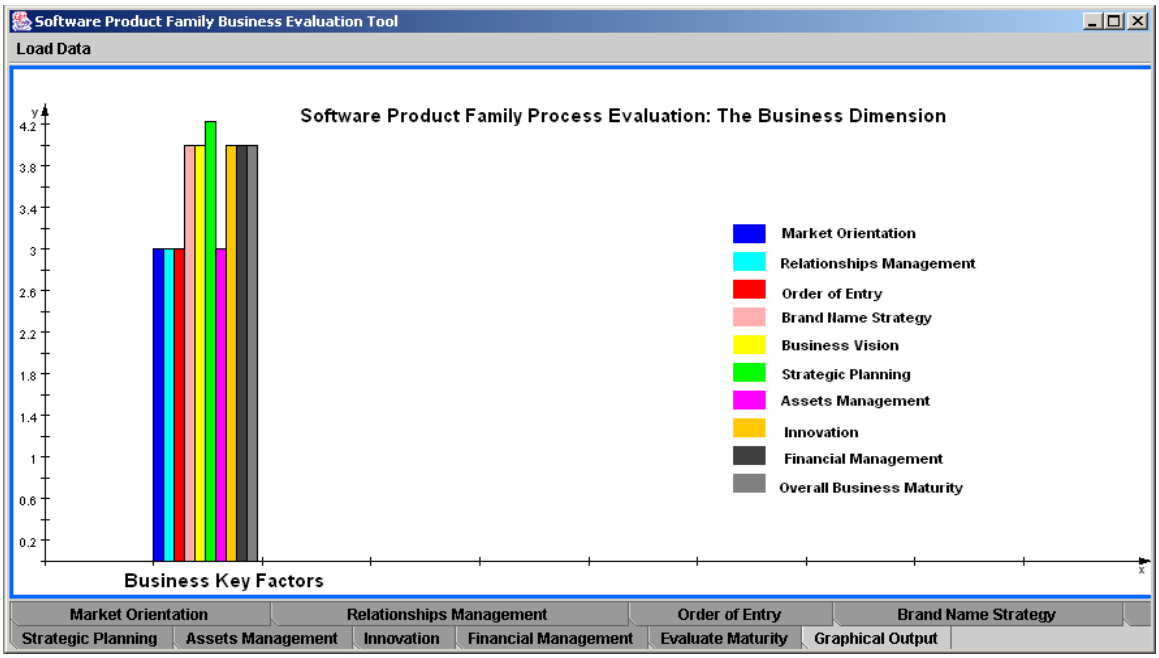

Figure 8: Output Screen Shot of Software Product Family Business Evaluation Tool

Figures 7 and 8 are input and output screen shots of the software product family business evaluation tool.

Case Study & Assessment Approach

Using the framework presented in this work, we conducted eight case studies in order to perform the business assessment of the organizations actively involved in software product family process. The input questionnaires shown in Tables 2 to 10 were distributed to the organizations in order to obtain actual data regarding the status of the software product family business within those organizations. The major sources of data, i.e., documents, plans, models and actors were identified after discussions with the organizations in order to reduce the chances of over-and-under estimation by human judgment in filling questionnaires and to increase the reliability of the approach. Table 13 illustrates some of the sources of data and actors involved in acquiring the data of key business factors of an organization. The organizations were requested to respond to each question in the questionnaires and to provide values in the range of 1 to 5 best reflecting their current process. The value "1" corresponds to a low rating (Strongly disagree) whereas the value "5" indicates a high rating (Strongly agree). After the questionnaires from the organizations were received, using SPFBET, data values were processed. The maturity of individual key business factor and overall business performance of the organizations are then evaluated. To demonstrate the application of the framework we are presenting the case study of only one organization in this paper, mainly due to length of the paper.

Business Key Process Area	Sources of Data	Department or Actor Title
Market Orientation	Market Analysis, Competitors Information Survey, Strategic Marketing Plans, Sales Mission Statement, Business Model, Advertising, Strategies, Competition and Buying Patterns, Sales Forecast, Product Portfolio, Domain Model	Sales Force, Marketing Strategist, Business Analyst Portfolio Analyst, Domain Engineer
Relationships Management	Sales Data, Customer Profiling and History, Customers Complaint Log, Product Promotions Plans and Effects, Product Advertising Plans, Public Relations, Procedures of Sales and Distribution, Customer Inquiries and Satisfactions Ratio	Customer Relation Officer Sales Force Customer Support Representative Product Developers Requirements Engineer
Order of Entry	Business Model, Competition and Buying Patterns, Product Launch Timings, Business Case Evaluation, Sales Projections, Sales Data, Market Trend Analysis, Domain Model	Sales Force, Business Analyst Marketing Strategist, Senior Management, Production Team Domain Engineer, Application Engineer
Brand Name Strategy	Business Model, Brand Strength, Sales and Distribution Procedures, Competition and Buying Patterns, Brand Competitors Threat Analysis, Product Portfolio, Domain Model	Sales Force Business Analyst Marketing Strategist Senior Top Management
Business Vision	Business Vision Statement	Senior Top Management
Strategic Planning	Strategic Planning Document, Strategic Plans Reviews, Strategic Planning Change Requests, Strategic Plans Implementation Guidelines, Organizational Communications Procedures	Senior Top Management Middle Management Supervisory Staff Product Developers
Assets Management	Core Assets Repository, Assets Utilization History, Product Log, Commonality Management, Product Features, Variability Management, Requirements Engineering Documents,	Developers System Analyst Requirements Engineer Assets Management Team
Innovation	Research Plans, Product Innovative Features, Research Financial Model, Competitors Product Analysis, Domain Model	Research Staff, Senior Top Management, Middle Management
Financial Management	Balance Sheet, Financial Statement, Projected Profit-Cost Analysis, Cash Flow, Sales Forecast	Financial Controller Senior Top Management

Table 13: Sources of Data of Business Evaluation Framework

Case Study

Organization "A" has been actively involved in the business of telecommunications and is one of the largest organizations in the mobile phone industry. The data provided by organization "A", shown in Table 14, illustrates their current business status of the software product family. Table 15 shows the results prepared by SPFBET, using the data provided by the organization. A number of key business factors, such as market orientation, relationships management, order of entry, and assets management are at the "Extrapolate" level. Brand name strategy, business vision, innovation, and financial management are at the "Proactive" level. The organization has also achieved the level of "Proactive" in the area of strategic planning, and is moving towards "Strategic" level. The overall business maturity of Organization "A" is found at "Proactive" level. This relatively higher level of

business performance depicts the organizational commitment and abilities to adopt the software product family business in a successful manner. However, Organization "A" can further increase its business performance by incorporating improvements in the categories of market orientation, relationship management, order of entry, assets management and innovation.

Business Key Factors	Question Number of Questionnaires									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Market Orientation	5	4	3	4	3	3	2	2	2	2
Relationships Management	4	1	3	3	2	4	4	2	2	2
Order of Entry	2	1	2	1	3	4	4	4	2	2
Brand Name Strategy	4	4	4	4	5	4	4	4	2	4
Business Vision	5	5	5	2	4	2	3	4	5	3
Strategic Planning	4	4	2	4	4	4	4	4	4	5
Assets Management	2	2	3	4	2	2	2	2	2	2
Innovation	4	4	4	4	4	4	4	3	4	4
Financial Management	5	4	5	4	3	4	4	4	3	4

Table 14: Business Assessment Input Data of Organization "A"

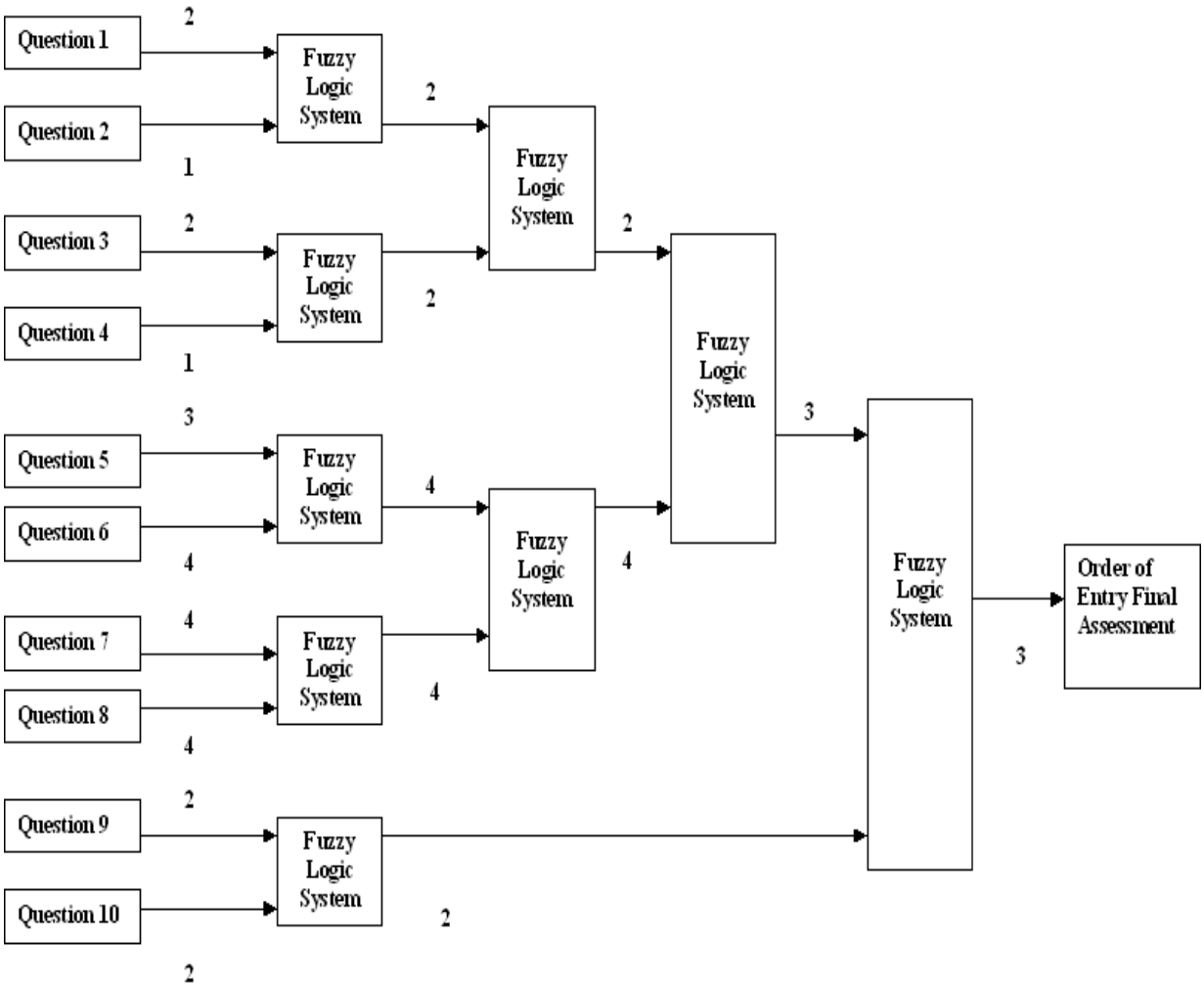

Figure 9: Order of Entry Intermediate Processing Sequence and Results Using SPFBET

Figure 9 describes the processing sequence and intermediate results collected at each of the stages of two-variable fuzzy logic systems during evaluation of key business factor of "order of entry" for this case study. The same structure and architecture is used for preprocessing and evaluation of all the other key business

factors. Figure 10 illustrates the processing of key business factors used to evaluate the overall business assessment of case study.

Business Key Factors	Maturity Value	Maturity Scale
Market Orientation	3	Extrapolate
Relationships Management	3	Extrapolate
Order of Entry	3	Extrapolate
Brand Name Strategy	4	Proactive
Business Vision	4	Proactive
Strategic Planning	4.22	Proactive to Strategic
Assets Management	3	Extrapolate
Innovation	4	Proactive
Financial Management	4	Proactive
Overall Business Evaluation	4	Proactive

Table 15: Business Performance of the Case Study

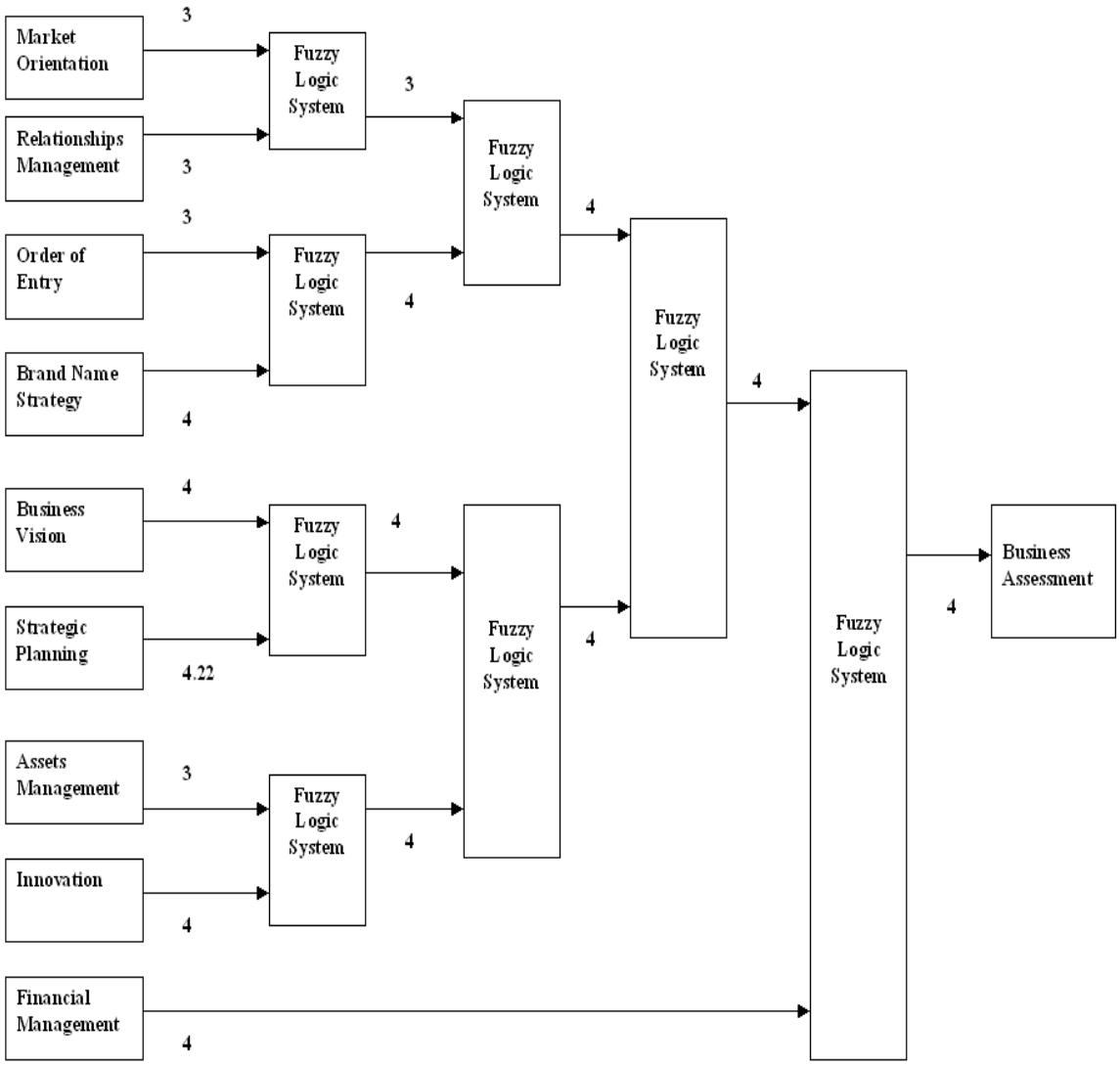

Figure 10: Intermediate Processing Sequence and Results of Business Assessment of Case Study using SPFBET

Final Remarks & Future Work

This research contributes towards establishing a comprehensive and unified strategy for maturity assessment of software product family process. An assessment framework for measuring the business dimension of software product family process has been put forward in this paper. The software product family business evaluation tool presented in this work can be used to preprocess the key business factors data and to evaluate the overall business maturity of an organization. The framework and tool provide direct mechanisms to measure the current maturity level of software product family business of an organization. The case study presented in this research shows the performance of an organization in the business of software product family, as well as demonstrates the application of the framework. Currently we are working on developing a Process Maturity Model for process assessment of software product families. This business assessment framework is a part of this research.

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