A Framework Approach to the Development of AI Applications

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Abstract

This paper describes how the technical, management and business lessons which the Information Technology Institute (ITI) of Singapore has gathered can be captured into a framework and made part of a learning organisation. The framework is a domain-specific methodology that ITI has developed for the reuse of valuable experiences. It is a market-driven, technologically-oriented approach to the management of related high-risk applications throughout their life cycles. An example of the use of this framework approach will be shared in this paper.

1. Introduction

Software organisations are often plagued with the questions of what new products to offer and how to deliver these products in the most efficient and effective manner. The Information Technology Institute of Singapore is no different. In response to our mission to create and deploy useful and innovative applications, we have developed a framework methodology for conceiving of a suite of products and applications. At the same time, this methodology will make explicit technical, management and business lessons, and hence, ensure perpetuity of such information beyond individuals.

This methodology is inspired by the evolution stages in the manufacturing industry, which has the benefit of many years of growth and research. It also draws upon the experiences of AI applications that have been developed by the institute.

From the need to have a planned approach to delivering more successes to Singapore and the AI community, and the benefit of prior experiences, we will share in this paper this framework methodology and an example of how it has been used.

2. The Car Manufacturing and Software Industries

Early in its history, the car industry was dominated by skilled craftsmen who produced each car to the specifications of their rich customers. Similarly, the software industry started off with customised applications for those who had the privilege of using the early computers. Each application had to be tailored to the characteristics of the hardware and the needs of the users.

With Model T, Ford revolutionised the industry with assembly line automation and improved productivity tremendously. In the software industry, it was also not long before the market saw the presence of off-the-shelf word-processing, spreadsheet and accounting software. It became possible to identify a class of applications which could be mass-produced. Software organisations could, hence, be more productive in development, customer support and maintenance.

Over time, consumers became more sophisticated. They were demanding cars of colours and accessories different from their neighbours. As competition became more intense in the car industry, manufacturers found the need to compete on quality, time and cost. The software industry is at this phase of development now. Intense competition has forced many players to focus on where they can value-add most to the industry.

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Continuous planning becomes of utmost importance. Companies need now to plan for resources to monitor the varying needs of customers, design a family of products to meet these needs, test the market, produce the products rapidly, promote them aggressively, and continually customise these products to the taste of each customer.

3. The Framework Methodology

Why A Framework Methodology?

The preceding scenario poses a big challenge to the AI application development industry. By nature, AI applications are highly-customised since they deal with human expertise, which is rarely uniform. AI applications are often risky too — requiring heavy investment of money and experts' time, and yet the payback can rarely be quantified up front.

Hence, a mechanism is necessary to deliver customised applications quickly. Fortunately, a fair amount of reuse is often possible. E.g. a reusable manpower rostering engine can schedule a large pool of staff to work shifts, adhering to a set of corporate policies and union regulations. Generic data representation structures could be provided to capture individual company's policies, union regulations and manpower information. However, the rostering engine need only know the abstract data structures to manipulate. Each expert's unique domain expertise can now be captured in a more structured manner. With a well-conceptualised generic engine, a software organisation will reduce risks to users through a better-tested engine.

What Is A Framework Methodology?

A framework is a long-term direction for a family of generic and robust suite of AI tools for a specific domain. A domain could be an industry such as the healthcare industry, or a type of activity such as rostering that takes place across a number of industries.

What should the framework constitute? The main ingredients are a workflow model of the interested domain, a technological scan, a deployment plan, reusable design and code, and management lessons.

The heart of the framework is the workflow. How does value get added along the value chain of the domain? Besides "how", other essential questions include who, why, what and when. Such questions can be answered through customised application development, as well as primary and secondary research. In the authors' opinion, feasibility studies represent the most cost-effective way of deriving domain information, without incurring the cost of actual application development.

The workflow model can help potential users identify and agree upon areas which can benefit from the introduction of relevant AI solutions. An explicit workflow model is also an ideal platform for continuous improvement.

The framework also contains a scan of the state-of-the-art products in the identified areas. Given an organisation's scarce resources and today's competitive environment, it is important to ensure that resources are consumed in adequately niche areas. Also, collaboration is a much better strategy than competition; the market scan can reveal valuable partners for which offerings can be strengthened.

The preceding information will lead to a deployment plan, taking into account an organisation's systems, market forces and likely competitor actions. Product offerings can then be planned over time, so that each product will build on the knowledge and experiences of the past.

The framework consists of reusable designs and code. Reuse will result in more robust software and speedier development. Improved quality and reduced costs can eventually be passed on to delighted customers.

This paper will not cover reuse methodologies. Instead we will deal with what we consider to be an operational approach to develop reusable code. A middle-out approach [1] to the development of the generic suite of tools can be undertaken, such that parallel development of a specific application and a set of generic modules ensure usefulness of generic modules and robustness of application. This approach is not without its pitfalls in that coordination between the two sub-teams can be tense. The delivery of the first few applications may be lengthened as time needs to be invested to design and test the generic modules.

The authors advocate development of generic modules in parallel or after adequate understanding of the domain

has been gained (through application development or feasibility studies). This is especially true in the field of AI where domain knowledge is key and work flow changes inevitable.

Management lessons such as team organisation, reward system, market planning and monitoring, and customer relationship management are explicitly captured in the framework. Such lessons include context as well as learning points. The purpose of these explicit information is to enable the organisation to learn to proliferate successes and avoid pitfalls.

No part of this framework is static. For it to be a real direction for an organisation, it needs to be constantly updated with technical, business and managerial lessons. As the marketplace changes and technology advances, a software institute may need to tie up with different partners or exploit different technologies to derive maximum benefit from the framework as a product direction [2]. As the domain also changes with the introduction of process re-engineering and new enabling technological wonders, the workflow model needs to be updated. With each new project, new management lessons can be gleaned and reflected in the framework.

4. The ITI Experience

The Information Technology Institute (ITI) has delivered many AI applications in the past eight years with and for various organisations in Singapore. Two applications have received the Innovative Application of Artificial Intelligence Award from the American Association of Artificial Intelligence (AAAI).

The Ship Planning System (SPS) is a scheduling system jointly developed with the Port of Singapore Authority for planning the loading and unloading of container ships [3]. With this system, the lead time for shippers to bring in their containers was halved from 8 to 4 hours.

The Automatic Layout Expert with Interactive Support (ALEXIS) system is an application which automates the layout of advertisements for Singapore's primary English language newspaper [4]. With the system, the daily production of the Appointments and Notices section of the newspaper was substantially reduced, from more than 4 hours to within half an hour.

The success of customised applications such as the Ship Planning System, ALEXIS, and others has built up ITI's strengths in the service industry. Up until 1992, we have developed a number of large-scale scheduling and resource allocation systems in the transportation industry. These were largely ad hoc application development efforts which often entailed the re-development of common modules each time. Some isolated attempts were made at developing reusable modules, but it was often uncertain how or whether these modules would be reused. It was also at this time that we realised that many components of the service industry's work flow are similar. A concerted effort is therefore needed to tie in such disparate efforts in order to achieve a consistent and efficient means of developing future applications in this domain.

It was with this in mind that in late 1992, we embarked on a project to define the needs and state-of-the-art in the management of service operations and resources, with particular emphasis on manpower resources in the service sector. Through secondary research and consolidation of prior application development experiences, some preliminary models were built. These models were verified through surveys and interviews. The information obtained from this project was used as the basis for the development of a Manpower/Service Management (MSM) framework [5, 6].

5. Manpower/Service Management Framework

Four conceptual branches were identified within the MSM framework, namely Resource Management, Activity Management, Manpower Planning, and Design & Analysis. Each branch is realised as a line of generic products and tools (see Figure 1).

- The *Design & Analysis* branch supports strategic decision making in the configuration of services to be provided. It is applicable to any organisation that has some degree of customer contact. For instance, a service layout module can simulate layout plans for a new service setup (e.g. a fast food outlet).

- The *Manpower Planning* branch is concerned with the manpower resource management aspects i.e. the growth of the manpower base to reach organisational objectives. The modules in this branch are useful in medium to large organisations, such as government boards, defense, airport and seaport service companies, and multinational corporations.

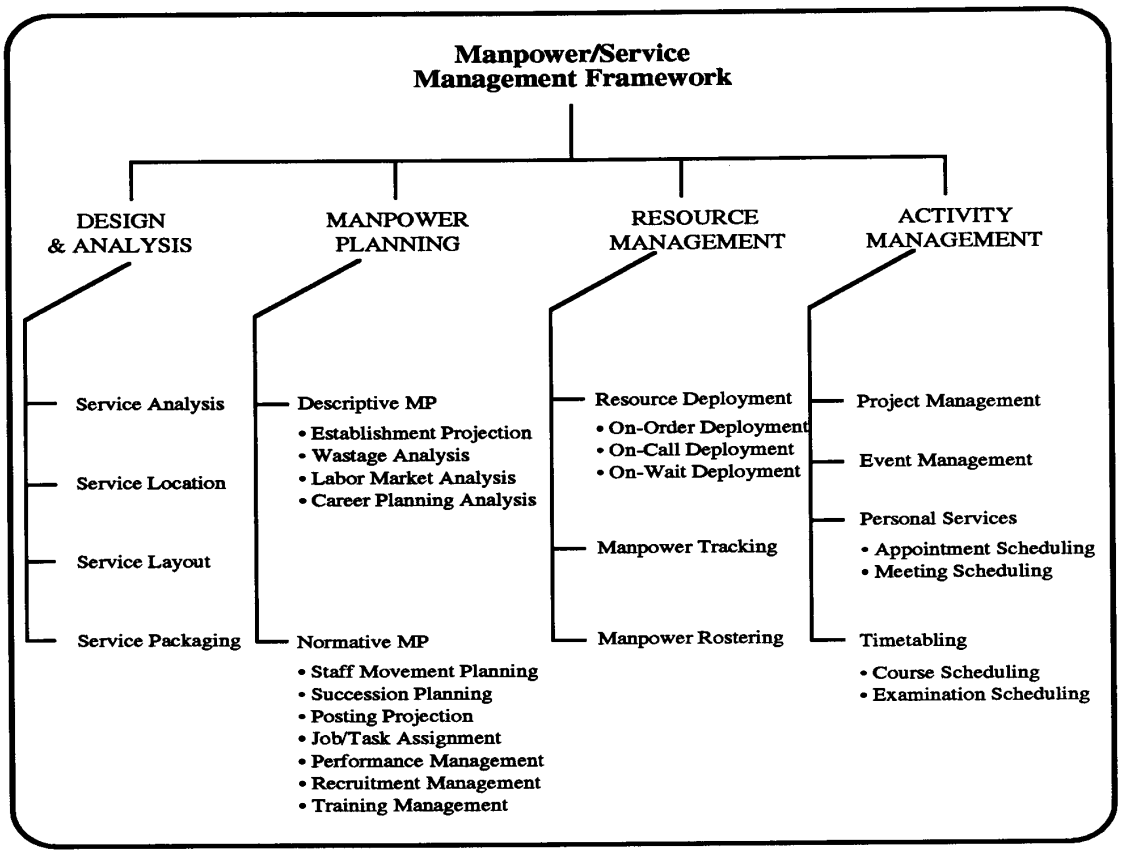

Figure 1: The Manpower/Service Management Framework

- The *Resource Management* branch encompasses application areas that are concerned with the efficient management of key resources (especially manpower) in a service organisation. These modules are applicable to airport and seaport companies that provide ground services, hospitals, fast food chains, hotels and public services such as the police, ambulance and fire services.

- The *Activity Management* branch is concerned with the planning of activities such that shared resources required by the activities are allocated effectively. For instance, the time-tabling module is useful in training institutes, while the event management module is applicable to organisations that plan large sports meets, conferences, trade fairs and major events.

The preceding conceptual branches are derived from our previous experiences and interviews with user organisations. Detailed workflow for modules of the branches is incrementally being built up through feasibility studies and prototype development. Such studies and prototypes increase users' confidence in our proposed solutions and enable us to incrementally extract valuable domain knowledge from our experts. The risks of full-scale AI application development are hence, reduced.

Each feasibility study is often accompanied by a product scan. This allows us to keep our initial list up-to-date with the latest product offerings. Contacts are also established with some local vendors to increase areas of collaboration. E.g. we work closely with some tool

vendors to continually incorporate their latest offerings in our solutions.

A deployment plan was drawn out immediately upon the conclusion of the initial framework study. A long-term plan identifying resources needed to develop all relevant modules of the framework was devised. The plan also proposed testing the framework with a manpower deployment system (to be discussed later). The deployment plan is constantly being revised with each project experience.

For products to be considered for development, reusable objects are identified and the Application Programming Interfaces agreed upon. This exercise is made easier because of the organisation's prior experience in similar areas. However, the authors have also noticed the dependence on the knowledge of individuals who have gone through such experiences. This observation gives greater impetus to the development of such a framework.

The middle-out development approach was adopted to test the framework architecture in the Resource Management area. A manpower deployment system was developed in parallel with generic objects. The result was a suite of generic objects that could also be applied across three applications, the manpower rostering system, the manpower tracking system and the manpower deployment system.

The middle-out approach that was applied was not without its drawbacks. Several practical management lessons were learnt from our development experience. First, the division of task. There were two alternatives: to have two groups of developers (one concentrating on the generic modules development and the other on the application-specific modules development), or to have sub-groups handling different functional modules (where each developer would have to wear two hats at the same time). We chose the former, trading-off communication overhead for code genericity. Second, we noticed the conflicting objectives of generic module developers with those of application developers. The former aimed for genericity and abstraction while the latter went for specific and quick implementation. For subsequent development, we would recommend a task rotation scheme to give each developer an opportunity to contribute to the generic modules as more applications are being developed. Third, we realised that the performance measurement criteria for the developers of generic modules played an important role. Very often, the effort contributed to the generic modules and its benefits were not apparent until after several applications have applied them. Criteria for measuring the effort of the generic modules developers have to be established upfront.

For our framework to be truly useful, it has to be continuously refined, adapted and evolved. As we develop more applications using existing components in the framework, new techniques, strategies and expertise will be incrementally captured to enhance the framework. We expect to deliver more robust applications to our users within a shorter time frame in the near future.

6. Conclusion

The framework methodology is still being refined in ITI. It is a corporate response to the market's need for quick, efficient and effective solutions. In the field of AI that is traditionally dependent on individual expert's knowledge, the framework is our means to speed up our understanding of our users' environment, and our delivery of the solution.

A framework consists of a systematically-captured repository of domain-specific information. A workflow model captures the value-add in the domain's value chain. A product scan identifies potential partners and tools upon which our solutions can be built. A deployment plan charts out immediate and long-term actions that various parts of the organisation needs to be prepared for. Reusable designs and code are useful towards speeding up the actual development of new solutions. And, finally, management lessons enable the software institute to learn actively. The framework will be the basis for iterations of planning, implementation and reflection.

A framework is not a panacea for today's dynamic environment. An organisation still requires strong leadership, effective management, talented developers and good relationships with partners. However, a framework points out areas for which core competencies can be developed and is definitely a critical success factor for any organisation today.

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