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Computer Aided Consulting for Small to Medium Businesses

Amjad Umar, Kamran Khalid, Nauman Javed and Adnan Javed
Fordham University, 113 W 60th St., New York, NY 10023, USA, umar@amjadumar.com

ABSTRACT

This paper describes a computer aided consulting environment that uses business patterns, best practices, inferences, and collaboration to recommend IT solutions for the modern SMBs (Small to Medium Businesses). This environment consists of a set of intelligent advisors that collaborate with each other in a fashion similar to a team of consultants to help a user walk through an extensive array of IT choices that include application planning, computer platform planning, network planning, and security planning.

INTRODUCTION

Small to medium businesses (SMBs) face numerous challenges in using IT. First, these businesses are increasingly relying on sophisticated information technologies such as the Internet, wireless networks, Web technologies, numerous application software packages, different types of security solutions, and a multitude of system software such as database managers, utilities, .Net Framework, and the like. Second, a great deal of in-house expertise does not exist to work through the technology maze. Third, many of these businesses are widely distributed and exist in small towns, houses, and remote areas as compared to large industrial complexes with easy access to solution providers. Finally, good quality consulting at affordable rates is not readily available for SMBs. Consider, for example, a small startup company with 50 employees — it needs to decide what to automate, what automation strategy to use, what type of applications packages to buy, what to rent and from where, what to outsource and how, what type of computing platforms to buy, whether to use wireless networks or not, and how to secure the company assets. These are difficult decisions, especially in the current highly fluctuating business and technology landscape. Somewhat fragmented approaches, such as the following, have appeared in the marketplace to provide partial solutions:

- Some providers have developed websites to sell their solutions. Examples are Cisco, IBM, SAP, Dell and other websites. However, the user has to go to Dell for computers, Cisco for networks, and third party vendors for application software.
- Some "SMB portals" have been developed by a few suppliers to help SMBs with business related issues. Some of these, such as BizMove (www.bizmove.com), concentrate on business issues of venture capital and legal services while others, such as IBM Small and Medium Business site (www.ibm.com/mediumbusiness), try to sell one supplier solutions.
- Some consulting groups have built their own automated tools to sell their own services [3, 5, 8]. These tools are oriented towards one supplier or consulting organization and are not largely geared towards SMBs.
- "Professional Services Automation (PSA)" solutions have been built as an extension of workforce management for professional service organizations [7] and have been promoted primarily by the Aberdeen Group (www.aberdeen.com). There are approximately 30 independent software vendors (ISVs) in the PSA marketplace, among them are Business Engine, Changepoint, Evolve, Niku, Novient and PeopleSoft. Despite the press on PSAs, these tools are basically targeted for internal efficiencies of service oriented companies and do not help the SMBs.
- Research prototypes and industrial expert systems that appear regularly in academic and industrial journals such as the IEEE Intelligent Systems, PCAI (www.PCAI.com), Expert Systems Journal, and AI Expert. While this is an excellent repository of research information, it does not directly help the SMBs develop IT solutions quickly and effectively.

To address these limitations, we have initiated research on "computer aided consulting" (CAC) in the same vein as computer aided design (CAD) and computer aided manufacturing (CAM). CAC aims to develop and deliver consulting services through software, especially Web, to quickly and cost-effectively solve end-user problems. CAC consists of a set of consolidated tools that provide a mixture of expert advise, professional service automation, and a knowledge portal. As a starting point, we have developed CACIT (Computer aided consulting for IT), a workbench for SMBs that attempts to capture and automate the essence of good consulting practices and, in particular, exploits the following common features of good consultants:

- Heavily rely on *inferences* to reach conclusions instead of asking too many irrelevant questions.
- Use *patterns* to capture the common and best practices instead of every possible point in the solution space.
- *Collaborate* with other consultants to solve complex problems, e.g., collaboration between a network expert and a security expert to develop a secure network.

Development of CACIT is based on our earlier research [9, 14, 15, 16] and the lessons learned in several real life consulting assignments. Our main research objective is to answer the question: can IT consulting services be completely automated, at least for SMBs, and if not, why not? Instead of building yet another prototype, we are working with a startup company to develop an industrial strength product that can be used by SMBs. We plan to use the knowledge gained from this research (technical, organizational, and behavioral) to larger settings.

COMPUTER AIDED CONSULTING FOR IT (CACIT)

The Conceptual Model

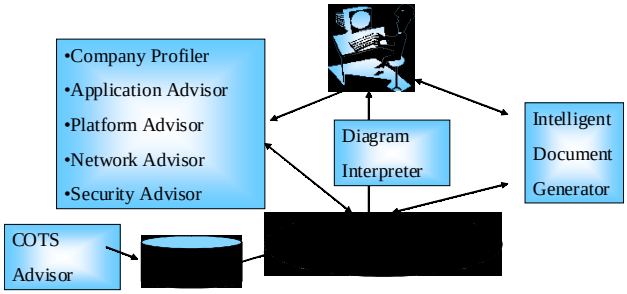
The CACIT platform consists of a set of *advisors* that collaborate with each other to solve IT problems for SMBs in a manner similar to a team of experts in real-life situations. For example, the network advisor suggests a network configuration by using inferences and patterns but then collaborates with the security advisor to secure the network. At the core of collaboration is a common "object" model (*OM*) that is refined and expanded as the advisors work on solving a particular problem. Basically, *OM* is a set which consists of several subsets and each subset is created by and maintained by an advisor. For example, $N \subset OM$ where N, itself a set, is created and maintained by the Network Advisor. To provide maximum flexibility, *OM* and all of its subsets, are implemented as XML documents. Figure 1 shows a conceptual view of the major components of CACIT:

- **Company Profiler a**llows each user to create an enterprise model that captures the company type, company size, workgroups (WGs), company sites, and allocation of WGs to sites. This model is used to infer business processes (BPs) based on business patterns [1] because each industry has a set of commonly used BPs. It also captures business process outsourcing [6, 10], a common way of conducting business at present. In essence, this profiler infers the BPs *{b1, b2, b3,,, bn}* that are needed to support a company and where these BPs are conducted. It develops a matrix *B* that shows the allocation of BP *j* to a site *k* (i.e., B*(j, k)* = 1 if *j* is allocated to *k*, 0 otherwise*)*. Note that *k* may be a site of the organization or an outsourced site. Similarly, a matrix *F* is developed to indicate allocation of workforce to sites. As we will see, *B* and *F* drive later decisions as they are used by other advisors. Additional information contained in the enterprise model is not discussed here due to space limitations. The enterprise model *E = {B, F, ..}* and is a subset of *OM*, i.e., *E* ⊂*OM*.
- **Application Advisor** suggests an application plan to automate the BPs based on the enterprise model *E* developed by the profiler. This advisor is a very powerful tool that allows a company to develop an automation strategy with different options of buy, rent, outsource development, build in-house, or re-use/re-engineer existing applications. In essence, this advisor takes the BPs inferred previously and builds the automation strategy matrix *T(j,a)* where *j* is a BP and *a* shows the automation strategy, i.e., *a = 0* indicates not automated, *a = 1* means buy, *a =2* means rental, etc. Thus *a > 0* indicates an automated BP. This advisor also helps the user in building an implementation strategy *I* that shows how exactly automation strategies could be implemented. For example, it helps the user to select the COTS (commercial-off-the-shelf) application packages that can be bought and suggests an application service provider (e.g., Corio and SAP) for rental and outsourcing. Implementation strategies are facilitated through a COTS Advisor, discussed later, that collects information about commercially available solutions. Additional information contained in the application plan is not discussed here due to space limitations. The application plan *A = {T,I, ..}* and is a subset of *OM*, i.e., *I*⊂*OM*.. Notice that at the end of an interview with this advisor, the *OM* contains the enterprise model and application plan (i.e., *OM = [E, A*]). Although only partially complete so far, the OM has very valuable information that shows which sites will be heavily automated, which ones will be not, and what automation strategy will be employed where. However, if the automation strategy at a site is rental by using an application service provider (ASP), then the site itself will not house the technology but will provide a link to an ASP (see, for example, [2], for a discussion of ASPs).
- **Platform Advisor** goes further by suggesting a computing platform plan that will "host" the applications selected previously. It performs three major functions. First, it recommends computing platforms for each site based on the role of the employees (manager, secretarial staff, professional staff, etc) and the type of activities performed at that site. These recommendations are inferred from the enterprise model *E* and the application model *A* constructed by the previous advisors. Second, it performs interdependency analysis by allocating the application packages to the platforms that support them (e.g., allocate Windows-based software to the Windows machines, not Linux). A challenging area is the interdependencies between the middleware services, operating systems, and application software. We are using our previous experience [9] and reviewing other research [11] for such descriptions. Finally, this advisor helps the company estimate the number of application servers based on a centralized versus distributed application processing strategy adopted by the company. In a centralized model, all applications processing is done on one large machine (or a few machines in the same room) at one site. In a distributed model, each workgroup or site could use their own application server for local application processing [16]. The advisor also considers the role of an ASP server. If ASP is used for some applications, then those applications are assigned to the "ASP" server. This advisor constructs a set *P*⊂*OM* that shows the computing platform (consisting of the computing hardware, system software, and middleware services).
- **Network Advisor** suggests a network plan that interconnects the computing platforms by using wireless as well as wired network elements. This advisor also performs three major functions. First, it infers the workload at each site by using inferences based on the OM that has been already constructed by the other advisors. Thus, without asking additional questions, it estimates the number of emails, average size per email, the number of web searches, and sizes, and access to remote databases, etc based on the type of work that is being performed at different sites as reflected by *B* and *F*. Second, it suggests a network configuration and estimates bandwidth needed by using queuing network models [23]. For example, it determines capacity of network devices inside the buildings and estimates bandwidth of connections between sites depending on the type of connection (wired/wireless) and the distance between the sites. Finally, it suggests the type of connections and the commercially available network solutions between local offices, regional office, and the Public Internet by consulting with the COTS Advisor. The Network Advisor constructs a set *N*⊂*OM* that shows the network plan. The plan includes wireless solutions (Wi-Fi, Bluetooth, wireless local loops, satellites), wired solutions (DSL, cable modem, T1, T3), and network interconnectivity devices (routers, wireless access points) from providers such as Cisco, Linksys, and others [13, 18].
- **Security Advisor** analyzes the security features of the OM developed so far and suggests a security plan that can be used to secure networks, databases, applications, platforms, and other objects. In particular, this advisor starts with the model *N* of the network produced by the Network Advisor and infers some security requirements from the BPs and the network model (e.g., a firewall must be placed to separate the external users from the internal users, administrative systems must have at least an ID-PW protection, etc.). The user is also guided to secure some sensitive objects such as corporate databases. The main work of this advisor is to conduct thorough security analysis based on attack trees [12]. The goal is to identify security weaknesses by constructing and launching attack trees. For example, the user picks a "critical" object such as a sensitive database and then launches attacks that could compromise the database. Each attack is triggered if a precondition is enabled. For example, a database cannot be read by a network sniffer or wireless antenna if encryption is being used. Thus, if encryption is used (precondition disabled), then the database privacy attack cannot be launched. .The attack tree analysis reveals areas of weaknesses for the different objects. Tradeoff analysis are performed to assess the risks associated with these weaknesses and make judgements by evaluating the tradeoffs between performance, cost, and security risks. Latest thinking in information security is used to protect the assets in the highly digital and mobile environments of today [19]. The Security Advisor constructs a set *S*⊂*OM* that shows the security plan with encryption, authorization, authentication, auditing, and other security approaches.

These advisors work with each other and build upon the knowledge of each other to develop a complete IT solution for SMBs. The solution is represented in the OM, where *OM = {E, A, P, N, S}*, that contains extremely rich information about the enterprise, application, computing platforms, networks, and security. These advisors also rely on the following components to provide a complete and comprehensive solution:

- **COTS Advisor** collaborates with all other advisors to provide commercially available solutions. This Advisor collects the COTS (Commercial Off the Shelf) instances of the various objects (e.g., software packages, routers, access points, computers,) and populates the Techbase – a relational database. The contents of the Techbase are used to update ("enrich") the object model by the

Figure 1. Conceptual View of CACIT



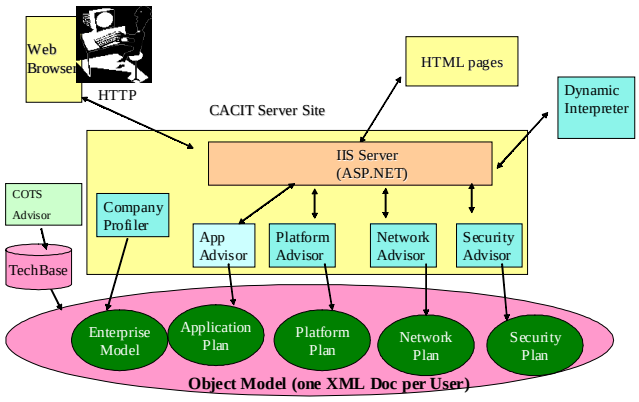
various advisors. The COTS Advisor is designed to extract information from various sites (based on input parameters), synthesize and categorize it based on an extensive ontology, and store the results in the Techbase for use by other advisors.

- **Diagram Interpreter** renders the object model to views by using Flash and Java Applets. The goal is to render the object model into a visual representation for the end user so that they can understand and modify the results if needed. This also includes a visual editor that can be used to edit the configurations shown to the user. The Diagram Interpreter is somewhat similar to Graphviz (www.research.att.com/sw/tools/graphviz/) in concept but it maintains semantic information to support different views needed by the various advisors. For example, it displays a high level business view, an application view, a network view, and a security view of the object model (OM).
- **Intelligent Document Generator** produces a document that captures the essence of the user interview and displays the key information contained in the OM. In other words, the generated document shows the main decisions made in the enterprise model (E), the application plan (A), the computer platform plan (P), the network plan (N), and the security plan (S), in an RFQ (request for quotation) format. This information can also be formatted to support purchasing decisions.

Technical Architecture of CACIT

CACIT is a Web-based system built by using .NET framework. The system resides on an IIS server and is accessible from commonly available Web browsers. Figure 2 shows the technical architecture of CACIT. All advisors are ASP.NET modules that run on the IIS server and are written in C#. We are currently investigating some rule based engines for future developments. All advisors are invoked from the CACIT controller that signs a user in and assigns a unique ID to the user. This allows each user to develop and store her own object model that is enriched as the user invokes different advisors. As stated previously, the object model (OM) is a set of XML documents that represent the results of the interviews as the user interacts with different advisors. After being invoked, each advisor conducts its own interview, consults the object model to review the decisions made so far, makes inferences as much as possible, makes further decisions based on the user interview, and further enriches the object model. The object model is used as a basis for collaboration between the advisors.

Figure 2. Technical Architecture of CACIT



AN SMB EXAMPLE: GENERAL FLOW OF THE SYSTEM

Let us illustrate the key points by considering a small manufacturing company with about 30 employees. CACIT uses this very simple and high level information to make several inferences and uses patterns to develop solutions quickly through its advisors.

The company type and size is used to quickly build the enterprise model by the Company Profiler. For example, the business processes (BPs) needed by the company can be inferred because the company will need to provide manufacturing and design processes in addition to the sales, marketing, and internal business processes such as human resources.

Some of the automation strategies are inferred by the Application Advisor. For example, this small company may need only a few application packages to support most of its business processes. In addition, renting through an ASP is a much more cost effective automation strategy for a small startup company.

Computing platforms needed by the company are inferred by the Platform Advisor. For example, desktops may be needed by the regular employees but powerful machines may be needed for CAD workers in the manufacturing department.

Computing network configurations are inferred by the Network Advisor. For example, the company may have workgroups such as administration, manufacturing, and sales. Each one of these workgroups may be a LAN segment that is interconnected through a corporate backbone. Workloads for performance models can also be inferred. For example, a clerk generates mainly emails but a CAD engineer may generate several downloads and Web surfing commands.

Some security requirements and security solutions are inferred by the Security Advisor. For example, manufacturing companies have fundamentally different security requirements than financial institutions. Typical security attacks and audits/controls for small manufacturing companies can be also inferred.

This quick example illustrates how the three principles (inferences, patterns, collaboration) provide a solid basis for a powerful CACIT workbench. Specifically, given basic information about a business many inferences about the business processes, applications, networks, platforms, architectures, security, and performance can be reached. These inferences do not lead to complete solutions but instead produce sketches (patterns) that are refined through additional questions by the advisors. For example, the computing platforms as well as computing networks generated above are too sketchy and are refined through additional questions. Finally, there is a need for collaboration between the solutions generated. For example, the network solution and the computing platform solution are used as an input to the Security Advisor to develop a security solution (you need to know what you are securing). In addition, the sketchy solutions are translated to an implementation view by consulting the COTS Advisor.

CONCLUDING COMMENTS AND FUTURE RESEARCH DIRECTIONS

The foundation of computer aided consulting is that high level inferences about a pattern can be refined successively through interactions with the user and different experts (advisors) to develop a solution that satisfies the user needs. The current version of CACIT, being used to teach IT courses in MBA programs, has produced very encouraging results and has demonstrated the technical and business feasibility of computer aided consulting. The students are first asked to develop IT

plan for an SMB and are later asked to use CACIT to solve the same problem. They then build models of different SMBs and develop IT plans by using CACIT. The focus on SMBs is deliberate to allow development of complete solutions. Based on our current experience, we are planning to use this tool in our consulting engagements with SMBs and publish results for the research community.

Future research and development directions include a wide range of activities to make the existing platform into a highly valuable computer-aided consulting tool for SMBs. For example, a new advisor is planned to deal with the architectural and integration issues for SMBs. This advisor will extend the current approaches [20, 21, 15] to guide the SMBs through the intricate architectural and integration decisions. We also intend to extend the enterprise model to capture more business intelligence based on review of business ontologies and represent the common business processes by using the recent developments in business process definition languages such as BPML, WS-BPEL, XPDL, and UML 2.0 [24]. The Application Advisor will be extended to provide more expert advice on automation strategies by using known methodologies such as critical success factors and some outsourcing models [6, 10]. The Platform and Network Advisors will be extended to capture the interdependencies between the various components based on the lessons learned from several efforts [22, 9, 11]. The Security Advisor will be extended to support detailed tradeoffs between security, performance, and availability [19]. In addition, although all advisors at present reside on one machine, we plan to make each advisor a Web Services component so that different advisors residing on different machines can collaborate with each other over HTTP.

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