ALEXIS: An Intelligent Layout Tool for Publishing

Hong-Gian Chew and Moung Liang

Information Technology Institute
71 Science Park Drive
Singapore 0511
honggian@iti.gov.sg

Philip Koh, Daniel Ong and Jen-Hoon Tan

Singapore Press Holdings
82 Genting Lane
Singapore 1334

Abstract

ALEXIS is a system developed to automate the layout of advertisements for a leading newspaper in Singapore. Its deployment was in line with a strategic move towards a virtual publishing environment. This new setup harbors the potential to significantly enhance the publisher's operational efficiency and improve services to its business partners. The success of ALEXIS as a pioneering effort provided the necessary impetus for similar projects in the pipeline. AI has played a key enabling role in the ALEXIS endeavor, bringing significant benefits to the user organization.

Introduction

As a leisure pursuit, jigsaw-puzzle fitting consistently captures the interest and imagination of the young and old alike. The challenge is easily understood but often tricky to surmount. As a commercial pursuit, the problem (more often referred to as 'layout' or 'packing') is economically important. It finds numerous application opportunities in such areas as vehicle loading, warehouse layout, material cutting, VLSI design and publishing.

In this paper, we present ALEXIS (acronym for **A**utomatic **L**ayout **EX**pert with **I**nteractive **S**upport), an application which automates the layout of advertisements for the Singapore Press Holdings (SPH). The core operational challenge is akin to jigsaw-puzzle fitting, except that all the pieces are rectangular.

The SPH is the major newspaper and magazine publisher in Singapore. In recent years, it actively pursues a vision to move towards a virtual publishing environment. Under this setup, information can be received, edited and laid out in full electronic form. By leveraging on the speed and flexibility of the electronic medium, the SPH will be well-positioned to improve its operational effectiveness and lower the cost of advertising on newspapers.

Advertisement layout is a key component in newspaper publishing. Automating this task is imperative to the success of implementing the new workflow. In March 1992, ALEXIS was commissioned to pioneer the advertisement layout in the *Appointments & Notices* (A&N) section of *The Straits Times*. Its success is expected to catalyze similar layout automation efforts in the SPH's other publications. The Information Technology Institute (ITI), the applied R&D arm of the National Computer Board, was invited to jointly undertake the development work.

For the remaining sections of this paper, we discuss the nature of the problem encountered, the importance of AI concepts and techniques in contributing to the project's success, the system deployment strategy and how the resulting system sharpens the competitive edge of the user organization.

Problem Description

The Manual Workflow

This section presents an overview of the key concepts and processes involved in the production of the A&N section prior to the introduction of ALEXIS. The appreciation of the issues involved helps one understand the motivation for developing the system.

Each newspaper advertisement (hereafter referred to as 'ad') is rectangular and has a defined width and height. An advertiser who wanted to place an ad will have to reserve a space through the SPH's ad booking system called AdNet. Each booking minimally specifies the width and height of the ad and the date of publication. When submitted by the advertiser at a later time, the ad artwork is printed on bromide paper in actual size. Within the A&N work scope,

every artwork will be measured against its booked size, trimmed to exact size and waxed.

Ordinarily, ads can be placed at any available positions across the ad pages. To minimize print costs, however, the ads have to be as closely packed together as possible. The ability to efficiently utilize the advertising space is hence critical, though difficult, to achieve.

The ad layout has two major constraints which further compound the difficulty of the layout task. One, a certain level of layout aesthetics must be preserved so that the final product is neat and highly readable. General aesthetics rules are available from the experts, though the specifics are often tricky to articulate.

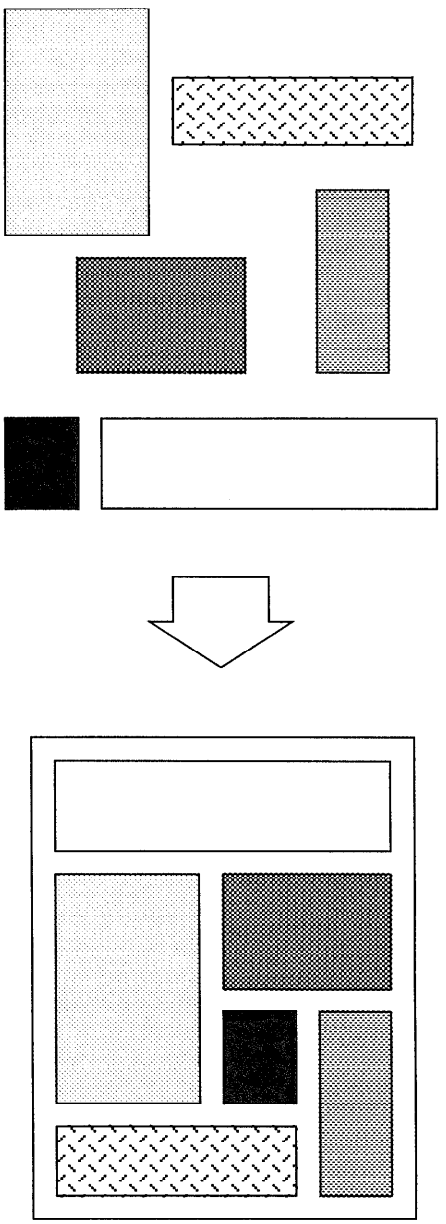

Figure 1: Solution to a sample problem

Two, it is possible for an advertiser to pay a premium for its ads to appear in certain pages or positions within a page. As an example, there may be a request to place an ad in the top-right corner of an odd-numbered page. Such requirements sometimes force the spaces to be fragmented and therefore increase the possibility of wastage.

Recognizing the importance of sophisticated layout expertise, a small team of well-trained experts were nurtured to specialize in A&N ad layouts.

The manual layout task undertaken everyday was complex and laborious. The human layout experts had to find a suitable placement for every ad within the designated ad pages. The process was akin to jigsaw-puzzle fitting, within the added pressure of working under tight operational deadlines.

A team of production staff assisted in the process by performing minor touch-ups to the overall page appearance. The end product is ready for printing. Figure 1 shows a sample of the final layout.

Problems of the Workflow

The manual workflow has two major drawbacks.

First, the layout process is too time-consuming and labor intensive. As a gauge of the tedium, laying out several hundred ads typically required a group of about six people to work continuously for more than two hours. Other supporting activities, such as measuring and trimming of ad bromides as well as validation of ad information, added to the man-hours expended. With the expected increase in printing press capacity and number of ads handled, the corresponding increase in labor requirements and production duration will soon become operationally unacceptable.

Second, using paper as a medium for pre-press layouts incurs typesetting costs, bromide wastage (as intermediate materials) and despatch expenses. Such costs undermine the attractiveness of advertising on newspapers as opposed to other media.

Objectives of ALEXIS

With the charter to improve the manual workflow, ALEXIS has two objectives: shorten the overall process duration and help the SPH move towards the envisioned virtual publishing environment.

Operationally, the target was to deploy one person to complete the entire layout task within 30 minutes (based on a task size of about 400 ads). In meeting this objective, ALEXIS has to ensure that the usage of advertising space is competitive with that of the human experts and that ad placement rules are consistently applied.

Strategically, ALEXIS will be integrated with the advertisers, ad booking system, ad image repositories and image-setters to form part of a virtual publishing community. Operational effectiveness is enhanced and unnecessary costs due to the paper medium can be substantially reduced.

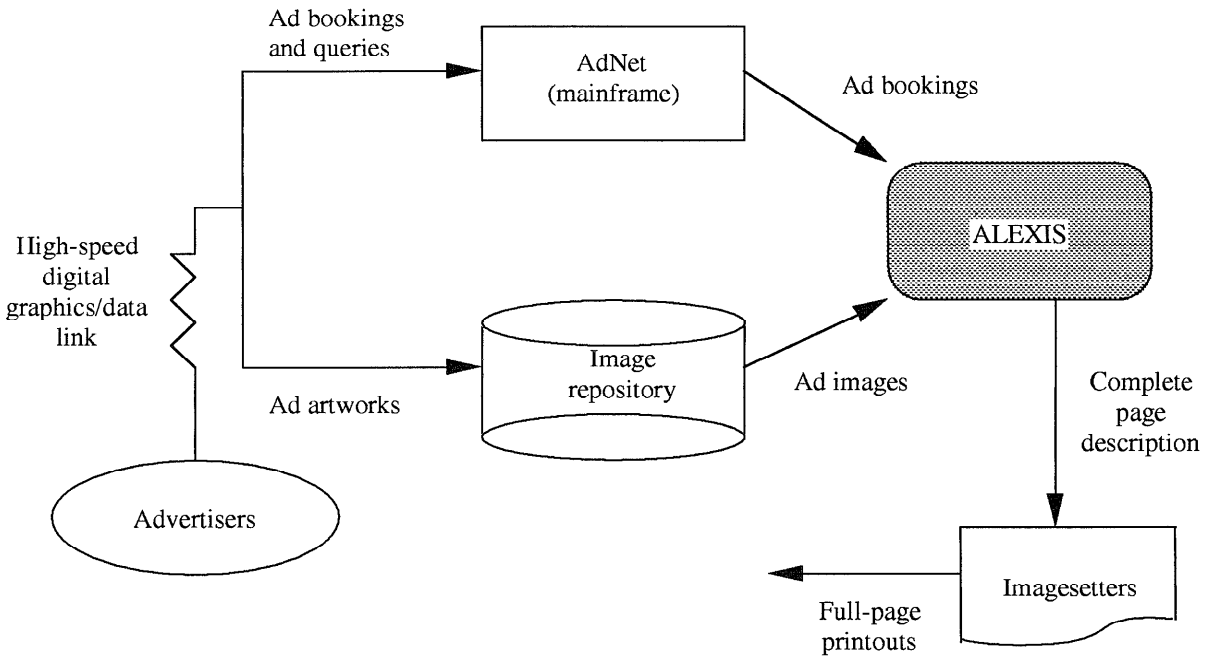

Figure 2: Overall architecture

Why an AI Solution was Important

The core technical challenge faced by ALEXIS is the difficulty in arriving at the final layout. The layout task as an optimization problem is well-studied and known to be NP-hard. In addition to this combinatorial complexity, the A&N layout is governed by more than 50 rules on layout aesthetics and how to meet advertisers' preferences for certain ad positions. Some of these rules are context-sensitive, difficult to articulate or subjective.

As stand-alone solutions, individual OR techniques for layout optimization often fall short of the time performance requirement because of the relatively large problem size. Approximation algorithms, on the other hand, run fast but do not yield satisfactory space utilization rates.

Shortcomings of the different algorithmic approaches were surfaced by the domain experts during a 3-month prototyping effort. Subsequent analyses pointed to a need for a meta-strategy to take advantage of the strengths of various techniques under different layout situations.

Standard algorithms are also not immediately amenable to the layout peculiarities such as position preferences of ads and layout aesthetics. With the help of the experts, these algorithms are enmeshed with heuristics and domain-specific shortcuts to achieve the desired results.

A cooperative problem-solving model is also introduced to help circumvent the problems of NP-hardness and quality subjectivity. The idea is to focus the user on high-level assessments of the layout quality and leave ALEXIS to provide the rudimentary layout capabilities based on appropriate user guidance. The desired layout can be achieved through rapid iterative improvements.

Application Description

A Re-engineered Environment

In reviewing the old workflow, it was clear that the operational target cannot be achieved by merely expediting the existing processes. The workflow needed to be revamped.

With the business objectives as the baseline, the workflow was repeatedly challenged, modified and refined. Processes which did not add value, particularly those arising from the use of paper-based layouts, were removed. In brainstorming the process transformations, conscious efforts were made to obtain maximum leverage from the automated layout capability of ALEXIS.

The intermediate re-engineered environments were put to operational tests. This approach was effective in evaluating the viability of process changes. The feedback was also critical in guiding subsequent recommendations.

Figure 2 shows how ALEXIS operates within the virtual publishing environment. Advertisers will continue to book advertising spaces through the AdNet system. Artworks for the ads may be submitted later through the high-speed digital links.

Layout of all the ads is done in ALEXIS. The system also provides a host of features to perform such supporting functions as extracting the ad images from the repository and adding the finishing touches. The entire page make-up is fully described and controlled electronically. The final layout, complete with text, images and graphics, can be routed to the image-setters for full-page printing.

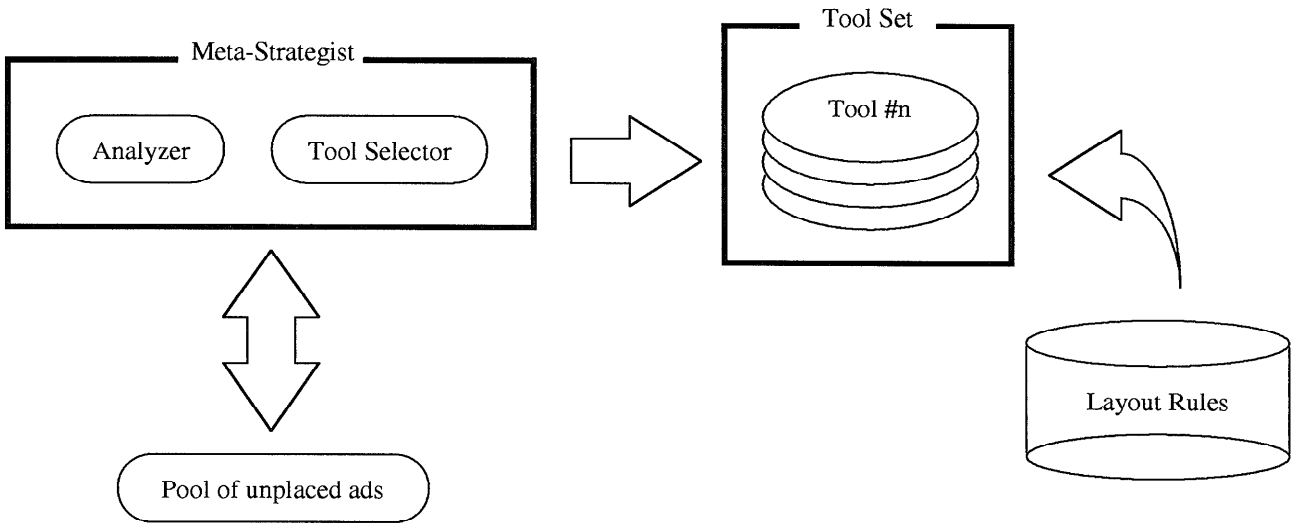

Figure 3: Architecture of the Layout Engine

Layout Engine

The core layout engine of ALEXIS, as shown in Figure 3, consists of a knowledge-based meta-strategist, a set of layout tools and a collection of layout rules.

The meta-strategist has two key components:

- *Analyzer*. In the course of observing how the human experts performed the layouts, the developers noted the benefit of pre-grouping ads prior to actual placement. Bigger-sized ads, for example, fit well with their smaller counterparts because the latter help to fill up the fragmented spaces.

  The analyzer encodes several beneficial ways to group ads.

- *Tool Selector*. For each cluster of ads sent by the Analyzer, the Tool Selector determines which of the layout tools can best complete the job within the time constraint and desired space utilization.

  The control knowledge embedded in the Tool Selector evolved through dialogues with the human experts on how to best exploit the strengths of different layout techniques. For example, when the task size is small, tools whose strategies are more exhaustive in nature should be favored. The rationale is that a task size is naturally associated with a small assortment of sizes. Any space fragment created in the course of the layout therefore has a lower chance of being filled by an ad (or collection of ads) with comparable area.

Two layout tools have been implemented. One uses a greedy search strategy in which ads are sorted and placed at the first available space. No backtracking is performed. This approach is fast but inconsistent in producing good utilization rates.

The other tool relies on a pattern enumeration technique. In essence, ads are repeatedly combined to form progressively larger blocks until the blocks approximate the page in size. Combinatorial explosion is checked by a set of stringent pruning criteria. The 'goodness' of intermediate blocks are assessed based on the minimum expected space wastage; they will be pruned if the wastage exceeds some predetermined threshold. This approach is time and memory intensive but produces compact layouts.

Each layout rule contains sufficient knowledge about how it can be satisfied or whether it has been violated by a particular ad placement. Layout rules are accessed by the tools in the course of every layout generation.

A Cooperative Problem-Solving Model

The intent of ALEXIS is not to replace the human expertise entirely, but to serve as a powerful assistant to its user. For this purpose, a supervisory control architecture was instituted. ALEXIS is not pressured to spend a lot of time searching for the globally best layout. It will, instead, rapidly produce a good initial solution and work on the advice of the user to seek progressive improvements. As ALEXIS already encapsulates the basic layout rules and space optimization criterion, convergence to the desired layout is often achieved in a short time.

To facilitate human-machine communication, ALEXIS provides a suite of interactive tools with which the user can suggest modifications. For example, suppose the user wants to fit a group of ads into the available space of a page. The desired collaboration mode is to have the user use his spatial judgement and domain experience to determine that the fit is feasible. The job of actually placing the ads, and possibly reshuffling the other ads within the page, is reduced to a better-tailored task which ALEXIS is competent to undertake. The speed and placement precision of the system is now exploited. Figures 4 and 5 give an instance of this principle in action.

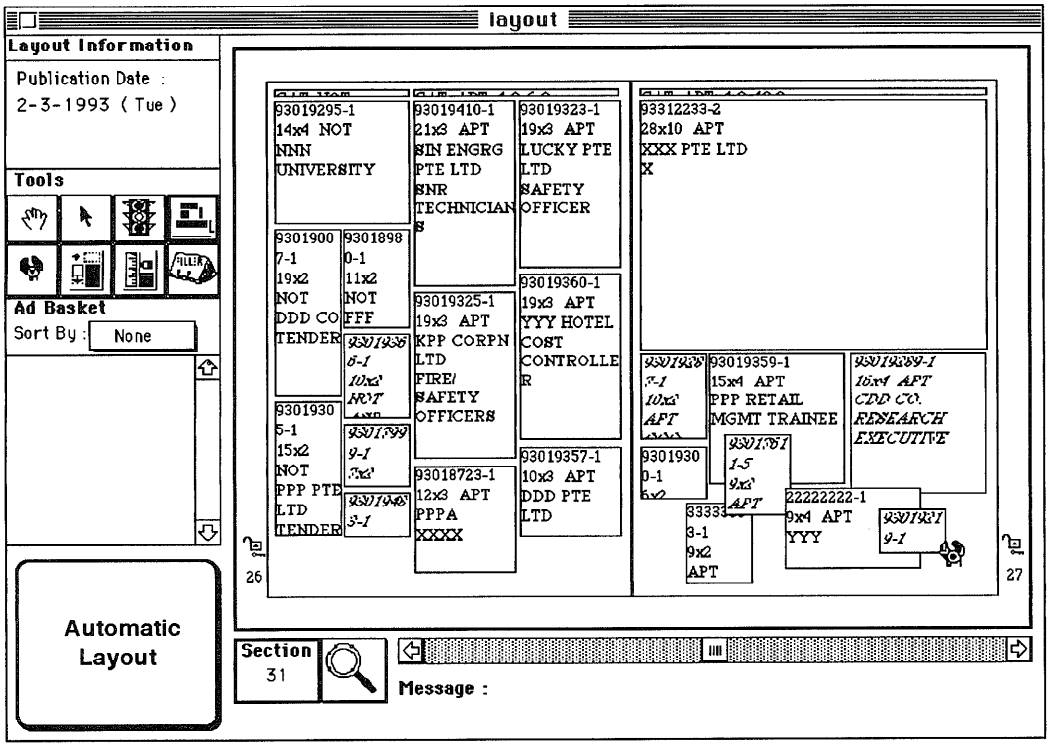

Figure 4: The user provides high-level layout guidance

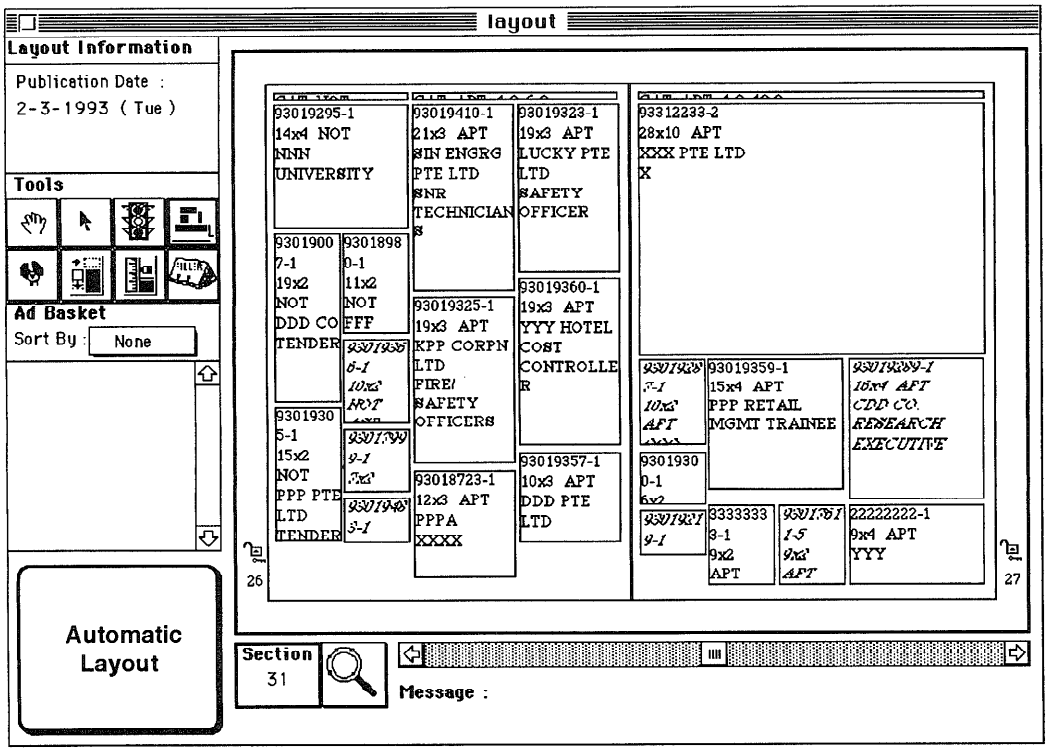

Figure 5: ALEXIS provides the automated support to complete the improvement

Maintenance

Efforts were directed to make the layout engine both modular and extensible. By applying object-oriented design concepts, the major components (i.e., meta-strategists, tool set and rule collection) are sufficiently decoupled so that changes can be localized within the individual components. Even the addition of a new layout tool is relatively easy to effect. Besides adding the new tool to the tool set, the control knowledge of Tool Selector needs to be updated so that the new tool can be appropriately invoked. Efforts to extend the capability of the layout engine are thereby simplified.

The majority of the layout rules have fairly structured representations. The following declaration describes a generic rule class. A rule can answer queries, typically posed by the layout tools, such as whether it has been violated or where an ad which obeys this rule can be placed within an available space. Rules which are more specific in terms of placement constraints are implemented by subclassing from the generic rule template.

```
class Rule {

protected:
   int ruleClass; // Rule grouping
   Ad * owner;    // Ad which obeys the rule

public:
   inline ItemRule (const int ruleClass,
                    void * newOwner);

   virtual Boolean IsViolated (Ad * a);
   /* Test if the current position of an ad
      violates the placement constraints
      imposed by this rule */

   virtual SuggestPlacement ();
   /* Assign position to an item based on
      rule interpretation */

   virtual Boolean CanQualify (Space * s);
   /* Test if rule permits an ad to be
      placed in a given space */
};
```

Given the well-defined interfaces of the rule objects, the team is currently exploring the possibility of introducing rule templates so that the maintenance task may be elevated to the level of the domain users.

Development Tools and Platform

As ALEXIS was delivered on the Macintosh platform, the development team used the MPW C++ compiler and MacApp user-interface libraries for its implementation.

The design and coding of the ALEXIS architecture adhered to object-oriented principles to achieve modularity, extensibility and ease of maintenance. ITI's in-house object-oriented design methodology guided the design process and activities.

Conscious efforts were directed to making the core layout engine platform-independent so that it may be easily ported to other new applications running on possibly different hardware platforms. Towards this end, the engine was developed and tested on Unix machines throughout the prototyping and development phase.

Application Development and Deployment

Development Schedule

A team of 3 developers (two from ITI and one from SPH) took 15 calendar months to complete the project. Of the total time spent, about 15% was spent to study the domain, formalize the requirements and elicit layout knowledge. Another 25% was expended on the architectural and detailed design. The remaining 60% efforts were distributed across coding, testing and deployment activities.

The total project cost, inclusive of hardware, software and development, was estimated at S$500 000.

Deployment Strategy

It was clear that the migration to the electronic workflow would not be an overnight exercise. Two main difficulties had to be addressed: acceptance of ALEXIS as an automated layout assistant, and operational adjustments to the new workflow. The team tackled both problems by adopting a two-phase deployment strategy.

In the first phase, the focus was to raise the operational competence of ALEXIS and gradually earn the confidence of the users in the system. To achieve this end, an alpha version of ALEXIS was stationed in the A&N work environment shortly after the design activities were completed. Though not fully functional, the system's capability was more palpable. Such access prompted the users to think more actively about how they could use this new entity to meet their operational objective . The developers also spent at least one day each week to participate in the users' tasks and observe the operational difficulties.

The alpha version served as an effective tool to calibrate the users' and developers' understanding of the real needs and how they can be met. Layouts generated by ALEXIS were constructively critiqued by the experts to surface missing or misinterpreted rule implementations. When opportunities arose, extrapolations of ALEXIS's capability were suggested to the users so that they can propose how the system ought to evolve. With the benefit of an extensible design, ALEXIS was iteratively improved, re-deployed and assessed. At the end of the first phase, ALEXIS was ready to be eased into the workflow.

In the second phase, the focus shifted to the operationalization of ALEXIS. The system was subjected to the time pressures and operational demands of daily production runs. The users also actively reshaped their work processes to achieve their operational performance targets.

When the second phase closed, ALEXIS was well-integrated into SPH's virtual publishing environment. This milestone also marked the end of ITI's involvement.

In retrospect, the incremental deployment strategy proved to be highly effective. Repeated iterations of the implement-deploy-feedback cycles not only improved the developers' appreciation of the domain needs but helped in the users' acceptance of the technology.

Application Use and Payoff

Current Status

By the end of June, 1993, ALEXIS was successfully delivered to the SPH. With the system providing effective automated support for layout tasks, daily productions of the A&N section can each be completed within the 30-minute target. Based on actual results, the space utilization rates yielded by ALEXIS were competitive with those produced by the human experts. Aesthetics of the layouts was not compromised as a result of automation.

The complete text and graphics descriptions of every page can be sent from ALEXIS to the imagesetters for full-page printing. The printed copies are, in turn, ready for transmission to the printing presses.

Perhaps the most significant benefit derived from ALEXIS is that the foundations for the envisaged electronic workflow are now firmly established. The SPH is now connected to several major advertising agencies in a pilot scheme to validate its virtual publishing environment. The results have been encouraging. Plans are now underway to expand the network connections.

Benefits

The success of ALEXIS in meeting its objectives is expected to bring significant benefits.

For the SPH, savings in labor, production floor space and bromides are estimated at S$800 000 each year. Leveraging on ALEXIS's layout speed, the organization can also handle the future growth in the number of published ads without the corresponding cost increases. By the same token, last-minute change requests from advertisers can be better served. Ad bookings can be added or withdrawn without unduly compromising the operational deadlines. Customer service is thus improved.

As business partners of the SPH, advertising agencies can look forward to annual cost avoidance of S$50 000 each since they can now save on typesetting, bromides and courier services under the new environment. In the process, the image of the SPH within the advertising industry is considerably enhanced.

The viability of ALEXIS has spurred the SPH to expand its efforts. On the drawing board is a two-year plan to apply the core engine of ALEXIS to the layout of ads in the main section of *The Straits Times*. Further cost reductions for the SPH and the advertising agencies are expected as the number of ads more than triples that of the A&N section.

Conclusion

The ALEXIS experience demonstrated that AI, in collaboration with other technologies, can enable a re-engineered environment. With the support and active involvement of management and users, the success of such an endeavor can significantly enhance business competitiveness.

Acknowledgments

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