Special Issue: SAICSIT '99
The South African Computer Journal
An official publication of the Computer Society of South Africa and the South African Institute of Computer Scientists

Die Suid-Afrikaanse Rekenaartydskrif
'n Amptelike publikasie van die Rekenaarvereniging van Suid-Afrika en die Suid-Afrikaanse Instituut vir Rekenaarwetenskaplikes

World-Wide Web: http://www.cs.up.ac.za/sacj/

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Preface

Philip Machanick, Overall Chair: SAICSIT'99

Running SAICSIT'99, the annual research conference of the South African Institute for Computer Scientists and Information Technologists, has been quite an experience.

SAICSIT represents Computer Science and Information Systems academics and professionals, mainly those with an interest in research. When I took over as SAICSIT president at the end of 1998, the conference had not previously been run as an international event. I decided that South African academics had enough international contacts to put together an international programme committee, and a South African conference would be of interest to the rest of the world.

I felt that we could make this transition at relatively low cost, given that we could advertise via mailing lists, and encourage electronic submission of papers (to reduce costs of redistributing papers for review).

The first prediction turned out to be correct, and we were able to put together a strong programme committee.

As a result, we had an unprecedented flood of papers: 100 submitted from 21 countries. As papers started to come in, it became apparent that we needed more reviewers. It was then that the value of the combination of old-fashioned networking (people who know people) and new-fashioned networking (the Internet) became apparent. While the Internet made it possible to convert SAICSIT into an international event at relatively low cost, the unexpected number of papers made it essential to find many additional reviewers on short notice. Without the speed of e-mail to track people down and to distribute papers for review, the review process would have taken weeks longer, and it would have been much more difficult to track down as many new reviewers in so little time.

Even so, the number of referees who were willing to help on short notice was a pleasant surprise.

The accepted papers cover an interesting range of subjects, from management-interest Information Systems, to theoretical Computer Science, with subjects including database, Java, temporal logic and implications of e-commerce for tax.

In addition, we were very fortunate in being able invite the president of the ACM, Barbara Simons as a keynote speaker. Consequently, the programme for SAICSIT'99 should be very interesting to a wide range of participants.

We were only able to find place in the proceedings for 36 papers out of the 100 submitted, of which only 24 are full research papers. While this number of papers is in line with our expectation of how many papers would be accepted in each category, we did not have a hard cut-off on the number of papers, but accepted all papers which were good enough, based on the reviews. Final selection was made by myself as Programme Chair, and Derrick Kourie, as editor of the South African Computer Journal. Additional papers are published via the conference web site.

We believe that we have put together a quality programme, and hope you will agree.

Acknowledgments

I would like to thank the South African Computer Journal production team, Andries Engelbrecht and Hema Viktor, respectively from the Department of Computer Science and Informatics, University of Pretoria, for their work on producing the proceedings.

The reviewers listed overleaf did an excellent job: many wrote very detailed reports, sometimes after being called in on very short notice. Inevitably, there were some glitches resulting from the unexpected workload, but the buck stops with the programme chair: I promise to do better next time.

I would also like to thank my own department for putting up with the extra work and expense that running a conference entails. I tried not to burden them with too much extra work, but our secretaries, Zahn Gowar and Leanne Reddy, inevitably had to take on some extra work. John Ostrowick provided valuable assistance with design of our web pages and call for papers poster. Carol Kernick, who handles our finances and membership records, did a fine job of keeping up with the demands of the conference.

Finally, I would like to thank our sponsors, whose contribution made this conference been possible:

- PricewaterhouseCoopers – sponsored generous prizes and the conference banquet
- National Research Foundation (NRF) – provided financial support
- University of the Witwatersrand – provided financial support
- Programme for Highly Dependable Systems, University of the Witwatersrand – provided financial support
- Standard Bank – provided financial support
Editorial

- Apple Computer – provided equipment for the conference
- Qualica – provided technical support including helping with the conference web site

Web Site

For more information about SAICSIT, including a pointer to the conference site, see <http://www.saicsit.org.za>.

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Experience Article

Distributed Operating Systems A Study In Applicability

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Abstract

This study will attempt to show the path of research and development of a huge and currently implemented SCADA (Supervisory Control and Data Acquisition) system product. The designers and their managers have identified movement to, and implementation of, distributed operating principles to be the only way to ensure the survival and competitive edge of the currently successful product implemented by IST Energy.

The field of Distributed Operating systems is not a new field, neither is it a small one. It is, however, a field under constant development where old theories which have not been proven in the field can now be implemented due to the hardware costs and constraints, like speed, becoming less and less a problem.

Due to the fact that computers and computing systems of various kinds permeate our everyday lives visibly and invisibly, the sheer amount of current hardware in the field makes any attempts at total replacement useless. That is why Distributed Operating theories which adhere to strong principles of interaction, autonomousness, linearization and integration are more valuable than short-term ideas which might move a system up a proverbial one-way street of development.

This study will:

- Explain the necessity and field of operation of this SCADA system currently in place,
- Point out the short-comings of the current system,
- the features necessary in the new system,
- how distributed operating principles are necessary, and could be implemented.

Keywords: SCADA, Distributed Operating Concepts, Real-World Application

Computing Review Categories: \textit{Cl}

1 The Current Feast Of Data

South Africa has a very modern and vast electricity supply network. This network consists of several types of generation methods varying from hydroelectricity and coal furnaces to old and dangerous atomic energy piles and modern Pebble-bed reactors currently under development. This type of electrical energy needs to be distributed from the, normally remote, dams and coal deposits. At this level, the amounts of energy being generated is enormous and needs to be handled carefully by huge and expensive machinery and computers. This energy has to be transported via landlines to many levels of intermediate branching and distribution with the least loss or chance of fault. At the lowest level, in the cities, the electricity supply must be stable, clean, cheap and reliable.

For such a network to comply to demands like uninterrupted, stable, constant quality clean and cheap electricity, expensive equipment and hardware is used. For example: A long-distance powerline can cost millions of rands per kilometer. If a short circuit (like a tree falling on it) should occur, it can completely ruin not only the cables but the billion-rand equipment busy generating the power. For this reason, thousands of devices are scattered over the network to detect and act on faults in milliseconds to localize and cut off supply to such faults. The subsequent loss of power to different sections of the country is also unacceptable, thus power needs to be rerouted in seconds, which means actuating million-Rand breakers with such reliability and speed to make these faults financially tolerable and undetectable to the end-user.

The SCADA system which is integrated with this electricity supply network, has as its main goal the acquisition, concentration and transportation of huge amounts of data. Every device, from the smallest substation in a neighborhood, to the turbine controllers in a hydro-electrical scheme are pools of data. There are literally thousands such pools. This data needs to be accessible. This is what IST's ICS (Integrated Control System) does.

2 The Old System

To explain the old system with insight and knowledge of distributed Operating Systems, the possibilities for improvement become obvious.
Controlling such a network effectively means giving the Control Centres at high level access to vast amounts of data quickly and reliably as to take correct decisions and actuating with virtually guaranteed success. A hierarchical ICS (Integrated Control System) structure has been performing this function for over seven years. Devices at all levels have the task to gather, convert, map, transport and concentrate data for different applications.

The hardware is based on the Motorola 68000 architecture with an operating system called OGRE. OGRE is a Round Robin multitasking operating system. OGRE has been surpassed in functionality and flexibility by such systems as VX Works, Windows CE and OS9. The interaction capabilities of this OS with modern workbenches is dwindling, and any company relying on this could be fading into obscurity along with its product. The move to principles of distributed OS is also limited if the operating system does not incorporate some of them automatically. As the Operating System cannot run C++ or Java, it limits this functionality. This makes replication non-trivial. Instead of being able to replicate data-serving through objects, it needs to be done in an old-fashioned way. This causes inflexibility and code-changes cannot be done with upgrades from a manufacturer.

A small to medium sized town with 20 substations can generate in excess of 50,000 plant points (of either analogue, status or control type). Approximately 100 processors are used for such a scenario task. A lot of calculations also need to be done at the lowest level for feedback purposes, and usually a round trip to the master station could include conversion to radio, microwave or telephone link and this might take too long.

The hierarchical structure of the dataflow in such a system is archaic and limiting in functionality. Although it is imperative that a Master Control Station be the pivotal point of functionality due to the risks involved, access to data in any other way, by another party is limited and needs extra coding every time. Giving read-access to certain data can ease maintenance and fault monitoring efforts by suppliers which need to monitor and check their equipment. Data access is limited because it is all very specific. A certain flow exists purely because of a structured client server relationship which is non-changing due to the fixed network configuration.

Configuring every single one of these hardware devices for the right communications protocols, data retrieval, addressing and calculations is a huge task. Many of these substations are geographically remote and reconfiguration due to negligence is not an uncommon task which is expensive and time-consuming. Remote reconfiguration is necessary, as well as automatic network reconfiguration ripple effects need to be implemented.

Communication takes place in a fixed and rigid manner. The configuration determines the master and slaves and these do not change. This causes single points of failure and inflexibility. Redundancy is hard to implement, so this is usually done only at master station level, with one level of redundancy.

The current implementation of SCADA by this company may become so inflexible to future customer needs that competitor's products may be more attractive to the clients.

3 DRDS - The Network Cloud Concept

The paying client is always the first one to come up with seemingly ridiculous new requirements. For example: The consulting engineer wants to access the oil-temperature of a transformer on the outskirts of Pofadder from his PC in Sandton, have a constant feed on this data and send automatic e-mail to the master station and cellular phone messages to himself should certain limits be exceeded. Also, should he wish, he must be able to reconfigure the parameters of the transformer from his house in the evenings. This has sparked the developers to think up new principles on which a new SCADA system should work. Some of the requirements are:

- On-line reconfigurability
- Transparent redundancy implementation
- Automatic Error recovery
- Automatic Network reconfiguration
- Easy access to selected data irrespective of source or destination.

These ideas will be integrated into the new Distributed Real-Time Data Server system. DRDS is IST Energy's current 3-year research and design project.

Figure 2 shows how a DRDS can interface dynamically at all levels, act as slave, master, client, server or peer and thus, in conjunction with other DRDS devices,
bring about the Network Cloud concept. This is very similar to the structure of the World-Wide-Web: Flexible and dynamic. It will, however, have retained its determinism and focus needed to function in a SCADA environment.

The characteristics of the system are the integration of a large number of independent data pools, geographically spread, with a large number of applications needing access to single pools, multiple pools, or certain parts of multiple pools.

The start of the development was the decision to change to a commercially available hardware platform. “One solution for achieving fault tolerance is to build software on top of specialized hardware” [4]. The PC104 card was chosen for this. This processor will run Windows CE. These are not the most exotic of tools for developers, but the business case for low-risk stability over the next 10 years is very strong.

The advantages of the hardware platform are interchangeability and cost. The advantages of the Operating System are a better development workbench, superior analytical and communication tools and a high degree of functionality which is implemented by the OS itself.

4 Distributed Operating Concepts
To The Rescue

A major source of information and ideas came from “The Process Group Approach to Reliable Distributed Computing” by Kenneth P. Birman [1]. The new system would re-characterize dataflow into an “Information Backplane” concept [1]. The Information Backplane will support a common naming structure, communication interfaces, access control, redundancy and history mechanism.

Two of the most important characteristics of the “Backplane” are:

- **Customization**
  
  Because the backplane will be organized in a systematic way, customization will be easier. This would mean subscribing to, and adding datasstreams while the system is active. Process Group principles can be implemented for this functionality.

- **Communications infrastructure**
  
  On a lower level, the communications infrastructure will make use of WAN and LAN concepts. Although also hierarchical, these nodes will not have single point of failure Masters in control. Instead, automatic reconfiguration of the LAN or WAN in the presence of failures will occur.

  As shown in Birman’s study, integration of distributed processes should not rely on communication performance for enhancement. Tools which can integrate individual and distributed components reliably, will make the whole system more reliable.

4.1 Process Groups

These arise naturally throughout a distributed system, but current distributed environments do little to support these. That is why current tools available through Windows CE will be used to implement functionality which comes close to mimicking the ideal process group environment.

In the network cloud environment, groups form due to subscription similarities. These groups may be geographically spread. What makes this concept so powerful is the fact that:

- the programmer need not be involved in group configuration, expansion or upkeep. What makes this possible is the group address, whereby entities subscribe to that address. If the sender and subscribers stay operational, messages will be delivered exactly once. In a LAN concept especially here, where control commands and ambiguity could render cities without power if used once too many, this proves to be very useful.

- The programmer need not worry about message loss or duplication. This leaves the design engineer with time to be creative with respect to function rather than problem solving due to communication difficulties.

- Messages will be received by the subscribers in a sensible order. This is important to a customer who has to worry about causality when switching between 110 000 Volt transmission lines in sequence.

For the developers, to attain such levels of distribution, synchronization and communication latency will be crucial. The fact that devices are geographically spread necessitates the use of various and simultaneous use of different kinds of communication media. These vary from ultrafast optic fibre, to very slow radio repeaters. It is counterproductive to slow the whole system down to get every chain as slow as the weakest link. Therefor, subscriptions should be carefully planned and managed, while communication upgrades are implemented over several years. In a
SCADA scenario learning from faults is can be financially fatal.

4.2 Failure Recovery

Another feature of distributed operating systems which could be of great use in this environment, is the fact that we will want to build systems guaranteed to make progress when failures occur. This is necessary because communication bandwidth requirements quadruple in the event of a fault on transmission lines. It is especially important for the system to keep functioning under these loads. The system has, in the past, gone into deadlock and thrashing status. These states need to be automatically recoverable after a communication surge.

Several ways of doing this with groups, is by integrating the communication transport layer with the failure detection layer to make processes appear to fail by halting. This is called a fail-stop scenario. When a process is dropped from a process group list, it is forced to either shut down gracefully or to run a reconnection protocol.

4.3 Replication And Redundancy

Location based replication [3] will be implemented due to large communication latency over such old and non-commercial communication links. Due to their criticality automatic reconfiguration of servers can be done using the same principles as used in the Advanced Automation System built for the US air traffic control system. These principles implement redundancy by state monitoring. For redundant servers to implement a service a “Loose Synchronization” [2] policy can be implemented.

Using current technologies to implement Groups requires a membership service, which if implemented by a single entity, becomes a single point of failure. Knowledge of group membership will be replicated amongst existing members of the group itself. In order to forego reconfiguration and re-startup by all, address expansion will be done in an integrated manner. This means that all members could act as server, but don’t because they all know who is the current acting server, and are constantly aware of its health.

5 A Final Note

The restriction of length of this paper restricts the scope and depth to which ideas can be discussed. Experience leaves the author with two conclusions regarding DOS: Integrating the DRDS with current 'old' technology instead of replacing it is inevitable due to cost. Also, all the principles and disciplines of Distributed Operating systems cannot be implemented all at once in a commercial environment. Risk makes a bad business case. The key for a successful product future is adhering to sound principles with a steady move to total replacement even if it is more difficult than implementing a quick fix.

Acknowledgements

The author would like to acknowledge this development as the combined efforts of the TCS Development Team of IST Energy.

References

not comprehensive. For example, what of mechanisms for visualising more than two concurrent events, and also concurrent events that do not have the same start and end times as each other. Extending the analysis would entail defining other ways in which the basic building blocks could be combined into structured eventualities; it would then be a matter of coding a PostScript routine for each additional structure. I argue that the modular approach taken would facilitate this kind of extension.

5.2 Related work

The work presented here is related to work on understanding instructions (e.g. [5],[4]); work on the object-eventuality analogy ([6],[9], [16]; work on visualisation of events and situations (e.g. [8], [10]). However, none of these deal with the issue of extracting and visualising information that is about repeated, extended or multiple eventualities.

There is an obvious connection with work in artificial creativity. We can see music and dance as artforms that exist in the eventuality domain and fine art existing in the object domain. It is clear that one aspect of aesthetic appeal in art comes from the recurrence of themes[7]; the repetition of musical phrases is a good example, while visually, say in a painting, patterns of repetition may be appealing. It would be useful to extend some of the models that exist of creativity[7] to include aspects of repetition and massness, in both the object and eventuality domains.

5.3 Summary

This paper describes an illustrative segment of an approach to representing the understanding of language about event sub-structure. Given a semantic analysis of the repetition described by instructions, it is possible to produce a visual image of this. PostScript’s functionality is exploited to provide a simple back-end to semantic analysis that is clean and modular. Additional event sub-structures can be included in a modular fashion.

Although the visualisation has some limitations, it is very useful in providing a means of representing semantic information in a medium that is distinct from the conventional ways of doing this, such as logical forms. Moving to a different medium has advantages that include being able to represent information that could not otherwise be easily represented, such as the passage of time. Also, applying the results of semantic processing to another application can be a good test of the validity of semantic output[8].

References


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15 Some detail has been omitted in order to simplify the exposition.
Notes for Contributors

The prime purpose of the journal is to publish original research papers in the fields of Computer Science and Information Systems, as well as shorter technical research notes. However, non-refereed review and exploratory articles of interest to the journal’s readers will be considered for publication under sections marked as Communications of Viewpoints. While English is the preferred language of the journal, papers in Afrikaans will also be accepted. Typed manuscripts for review should be submitted in triplicate to the editor.

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- Use wide margins and 1½ or double spacing.
- The first page should include:
  - the title (as brief as possible)
  - the author’s initials and surname
  - the author’s affiliation and address
  - an abstract of less than 200 words
  - an appropriate keyword list
  - a list of relevant Computing Review Categories
  - Tables and figures should be numbered and titled.
- References should be listed at the end of the text in alphabetic order of the (first) author’s surname, and should be cited in the text according to the Harvard method.

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