DISTRIBUTED COMPUTER CONTROL SYSTEMS 1985

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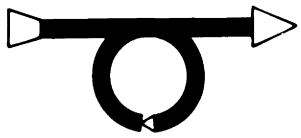
G. J. SUSKI



IFAC

International Federation of Automatic Control

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Proceedings of the Sixth IFAC Workshop
Monterey, California, USA, 20–22 May 1985

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SIXTH IFAC WORKSHOP ON DISTRIBUTED COMPUTER CONTROL SYSTEMS 1985

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The Lawrence Livermore National Laboratory, Electronics Engineering Department
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PREFACE

In May, 1985, the Sixth IFAC Workshop on Distributed Computer Control Systems was held in Monterey, California, U.S.A. Over half the attendees were from outside the United States, representing fifteen different countries. This diversity among attendees enriched the workshop by giving it a broad perspective. Correspondingly, a core group of regular workshop participants supplied continuity and focus resulting in excellent interchanges on distributed computer control system design methodologies, philosophies, activities, and future directions.

This sixth workshop in the DCCS series continued the successful format set in past events. The workshop was organized into eight formal sessions chaired by past DCCS workshop contributors. In each session, prepared papers were presented, followed by a short question and answer period. A general discussion period at the end of each session provided opportunities to clarify and explore the ideas raised in the papers.

Edited transcriptions of these discussions have been included in these proceedings. They represent an essential component of this workshop--its interactive interchange of ideas.

The second day of the three day event was reserved for tours and demonstrations of major control system activities at the Lawrence Livermore National Laboratory. A series of presentations there helped to generate areas of subsequent discussion and provided vivid examples of several topics discussed on the first day.

This workshop revisited many of the traditional issues covered in previous events. The assessment of the participants was that these issues remain relevant due to the continually evolving hardware and software technology being applied to distributed computer control systems. Considerations as to hierarchical vs bus architectures, broadcast vs token-passing communications schemes, the amount and levels of distribution, closed vs open architectures, and the general impact of standards on the DCCS area are all affected by new technologies.

New areas began to receive emphasis in this workshop. The advent of the next generation of control systems, in which the distributed control system is integrated into management information systems raises new questions in the areas of internetwork standards and performance, architectures, and functional distribution. Flexible manufacturing systems technology is incorporating new products, devices, and standards which will become pervasive in many DCCS applications. In the theoretical area, it was noted that the evolution of tools for modeling and simulating control system operation is such that we may now begin to investigate the feasibility of proving the correctness of control system designs and implementations. The generally increasing emphasis on theory and modeling methods raised the question of what areas should be emphasized in future workshops.

A highlight of the workshop was the interactive roundtable following the eighth and final session. In a series of statements and subsequent discussions led by key workshop participants, the essential ideas and issues raised over the three day event were summarized and clarified. Several topics were identified as important areas of discussion in future workshops. The edited transcript of this session is to be found at the end of these proceedings.

The Organizing Chairman of the workshop would like to extend his thanks to his organization, the Lawrence Livermore National Laboratory, for their participation in this event, and special appreciation to the Co-Chairman Milt Maxwell and his Factory Automation Group of Colgate-Palmolive Corporation, for their organizational and financial assistance in DCCS-85. The tireless efforts of the National Organizing Committee members, particularly Betita Gamble, Fred Holloway, Dianna Leap, Paula Maxwell, and Donna Nowell are gratefully acknowledged. Their extensive efforts in planning and executing both the workshop and its social programs were invaluable. The transcription and assembly of these proceedings was accomplished through the prodding and assistance provided by my secretary, Jo Dee Beck. Finally, the workshop registrar and administrative chairperson, Rita Bonivert was, more than any other single individual, responsible for the workshop's overall success and the satisfaction of its participants. Her dedication to the effort is sincerely appreciated.

CONTENTS

WELCOMING ADDRESS

M. G. Rodd

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On behalf of Tom Harrison and myself, I would like to welcome all the delegates to this workshop, set in a most beautiful part of the globe. The DCCS Workshop has become one of the Computers Committee's major on-going events, and is notable for two particular aspects:

First, it has maintained a consistently high technical standard and many ideas have been introduced here which ultimately have become accepted industrial practice. For example, methods of handling real time consistency in distributed systems.

Second, and probably one of the main reasons for the continuing high standard of debate and interaction, has been the real time consistency of attendees. Typically forty per cent of one year's delegates return the next year. This has ensured that the workshop atmosphere is quickly established--clearly reflected in the proceedings which contain verbatim reports of the discussion sessions. The workshop itself has done much to disseminate information in the topic of concern throughout the world, and is probably the most widely traveled event in IFAC's calendar. Having moved to virtually every part of the globe--thus also achieving distribution.

On behalf of the Chairman and Vice-Chairman of the Computers Committee, I would like to thank Greg Suski and Warren Gellie, Chairmen of the NOC and IPC respectively, for their tremendous efforts in ensuring the scene is set for another very successful event.

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REAL-TIME DISTRIBUTED COMPUTER CONTROL IN FLEXIBLE MANUFACTURING SYSTEMS

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Abstract As Computer Integrated Manufacturing becomes a reality, issues relating to the computer networks which are the backbone of such innovations require careful consideration. Whilst local area network proposals, such as the General Motors MAP initiative, are of great significance at the factory-wide level, problems at the lowest level of such systems are not really being addressed. This paper focuses on aspects of the communication requirements between components in a localized Flexible Manufacturing System, sometimes called an Island of Automation. These issues predominantly surround the problems of co-ordination and synchronization in multiple-robot situations. The paper suggests that there are three areas of particular importance in such a Flexible Manufacturing System, relating to synchronization of real-time activities, consistency of real-time data bases, and the scheduling activities within the FMS. This latter aspect is particularly important when one considers the possibility of failure in a part of the FMS, in which case dynamic rescheduling becomes essential. The paper discusses how the real-time network proposals which have been produced by the authors in the past are now applicable in this new situation. The system under discussion in this paper has been designed and is currently being implemented in a working, full-scale model of a Computer Integrated Factory.

Keywords Distributed Computer Control Systems, Real-Time Systems, Flexible Manufacturing Systems, Computer Integrated Manufacturing, Local Area Networks in FMS, Distributed Data Bases.

1. INTRODUCTION

Driven by economic forces and supported by diverse high-technology developments, the "factory of the future" is rapidly becoming the "factory of the present", not necessarily in its entirety but certainly in some areas. Over many years the Industrial Engineer has developed a variety of production and manufacturing tools to assist him in improving his manufacturing procedures. Many of these tools are essentially computer-based and an obvious step is towards integration of the various components available so as to strive towards an integrated whole. The total scenario possible is illustrated in Fig. 1. This figure shows that manufacturing can be supported in five different areas ranging from manufacturing management and computer-assisted engineering through operations control to warehousing systems, and finally down to computer aided manufacturing - the sharp end of the factory.

The "glue" necessary to bring all these tools together comes out of the computer networking tube, and if properly supported by integrated data bases etc., the benefits of an all-embracing plant-wide control and management structure become possible.

Whilst the totally-integrated manufacturing system starts at the data processing end of the factory using traditional computing technology, on the shop floor one sees various new tools such as numerically controlled machines, automatic test systems, assembly structures, welding equipment, painting systems, etc. gradually coming together to the benefit of the manufacturer. Such systems are loosely referred to as "Flexible Manufacturing Systems" organized as "Islands of Automation". In essence the term FMS implies that the various components required in the manufacturing situation are configured in a highly flexible fashion so as to offer greater utilization of installed equipment and freedom to change the items being produced. Inherent flexibility, however, is of little consequence if it is not controlled or organized properly and it is here that robots and computer networks play an important role.

The term "flexible" is, nevertheless, a vital one. The key to modern manufacturing methods must be the ability to reconfigure the manufacturing system to meet changing conditions, even changes which may occur, either by design or by default, work-piece by work-piece. Some manufacturing systems already in existence can cope with the machining of hundreds of different components, utilizing a set range of installed facilities - for example, the "SCAMP" Flexible Manufacturing System at Colchester, England. The technique used should allow for small-to-medium batch sizes, and should aim at maximum utilization of the installed equipment. The advantages of Flexible Manufacturing Systems are well documented [Ref. 1] and the MechaTronics Research Facility of the University of the Witwatersrand Technology Centre was established to create such a facility as a basis for research as well as for technology transfer purposes. The reasons for this venture have been documented elsewhere [Ref. 2]. In creating such a facility it became clear that the question of support computer networks had to be considered in some depth, and a close tie-in with the University's Distributed Computer Control Systems Research Programme became essential. Whilst it was clear that the higher levels of communication in a Computer Integrated Manufacturing System are well catered for by proposals such as General Motors' MAP (Manufacturing Automation Protocol) [Ref. 3 & 4], the lower levels in the automation hierarchy (necessitating the utilization of real-time, high-