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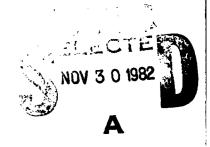
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FINAL REPORT

Development of Distributed Computing Systems
Software Design Methodologies

Stephen S. Yau

September 22, 1980 - July 31, 1982

U. S. Army Research Office

Contract No. DAAG29-80-K-0092

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	AD-A121941	

4. TITLE *(and Subtitle)*	5 TYPE OF REPORT & PERIOD COVERED
Final Report of the Project, "Development of Distributed Computing Systems Software Design Methodologies"	Final Report Sept.22,'80 - July31,'82
	6 PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
Stephen S. Yau	DAAG29-80-K-0092

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Dept. of Elec. Engrg. & Computer Science Northwestern University Evanston, Illinois 60201	

11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
U. S. Army Research Office Post Office Box 12211 Research Triangle Park, NC 27709	November 5, 1982
	13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*
Same	Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

NA

18. SUPPLEMENTARY NOTES

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Distributed computer systems software, design methodologies, atrributed grammars, Petri nets, desgin representations.

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report summarizes the important results obtained during the project period. One important result is the development of a design representation technique based on attributed grammars. The other is the development of a design approach based on Petri nets emphasizing modularity. Both results have been presented in detail in papers published or to be published in the scientific journals or conferecne proceedings.

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This project was originally proposed for a three-year duration. Because of the uncertainty of the funding situation, it was approved for the first year - from September 22, 1980 to September 21, 1981. The funding for the second and third years did not materialize, and consequently we requested no-cost extension to July 31, 1982. Therefore, the research we did during this period is only the first part of what we originally proposed for this project.

I. Statement of the Problems Studied:

During this period, we have studied the following specific problems:

1. Developing a formal methodology for distributed computing systems software design based on attributed grammars.

2. Developing a method of distributed computing systems software design using modified Petri nets.

3. Investigating the problems of reconfiguration and recovery for fault tolerance of distributed computing systems software.

II. Summary of Most Important Accomplishments:

During this period, the most important results we have obtained are the development of a formal representation of distributed computing system software design using attributed grammars, and the development of an approach to distributed computing system design using Petri nets. We will summarize these results separately.

A design representation technique based on attributed grammars emphasizing the constrution of a formal model of the distributed computing systems software design has been developed. The model allows for consistency checking of the design and for the possibility of run-time validation of the implementation. The software design is represented as a series of production rules for an attributed grammar. The control flow of the software system is governed by these production rules and by the attributes associated with the symbols in the productions. The major advantage of the attributed grammar approach is its ability to provide a common model from which it is possible to verify consistency among the design, implementation, and testing phases. Detailed results are presented in Paper No.4 listed in Section III.

Another design approach based on Petri nets has been studied which emphasizes modularity. Graphical "communication modules" which represent various mechanisms for message passing based communication allow the designer to introduce a level of abstraction into the design specifications. The major advantage of the Petri net approach is its ability to explicitly represent concurrency and synchronization as well as various forms of message based communication mechanisms. Detailed results are presented in Paper No. 2 and No. 3 listed in Section III.

These two design methods provide very useful and systematic ways to develop high-quality distributed computing systems software for real-time military applications. These methodologies will enhance the reliability, survivability and performance of distributed computing systems as well as decrease the cost throughout the software development cycle.

III. **Publications** and **Technical** **Presentations:**

1. S. S. Yau, C. C. Yang and S. M. Shatz, "An Approach to Distributed Computing System Software Design," IEEE Transactions on Software Engineering, Vol.SE-7, No.4, pp.427-436, July 1981.

2. S. S. Yau and M. U. Caglayan, "Distributed Software Design Representation Using Modified Petri Nets," Proc. Symposium on Reliability in Distributed Software and Database, July 21-22, 1981, pp.150-167.

3. S. S. Yau and S. Shatz, "On Communication in the Design of Software Components of Distributed Computer Systems," Proc. 3rd International Conf. on Distributed Computing Systems, October 18-22, 1982, pp.280-287.

4. P. M. Lu, S. S. Yau and W. Hong, "A Formal Methodology Using Attributed Grammars for Multiprocessing System Design, Part I : Design, and Part II : Validation," to be published in Journal of Information Sciences.

Besides the presentation of Paper No. 2 and No. 3, the following presentations were made during this period at no cost to the project.

1. "Methodologies for Distributed System Design," Fujitsu Laboratories, Kanagawa-Ken, Japan, October 9, 1980.

2. "Software Design Representation for Distributed Computer Systems," Sino-American Computer Conference, Palo Alto, California, November 2-6, 1981.

IV. <u>Scientific Personnel Participated in the Project</u>:

Besides the principal investigator Professor S. S. Yau, the following graduate students participated in and were partially employed on the project.

Mehmet U. Caglayan was supported by the project for the summer of 1981 and completed the Ph.D. degree in August, 1981 with the dissertation, "A Method for the Design, Representation and Analysis of Distributed Software Systems Using Modified Petri Nets."

Sol M. Shatz was supported by the project for 13.5 months and completed the M.S. degree in August, 1981 with the thesis, "A Modular Communication Based Approach to the Design of Distributed Software Components."

Wonmo Hong was supported by the project for the summer of 1981 and completed the M.S. degree in October, 1982, "Performance Analysis of Slotted Nonpersistent CSMA-with-Truncation Protocol for Local Computer Networks."

Ernest S. Lee was supported on the project for six months.