Intellectual Merit

application domains can inform each other to bring about new solutions that might not be imagined otherwise.

no other current or pending proposals that deal with the subject matter described in this proposal.

research is high-risk in nature because of the complexity of the abstraction models considered. Finally, the PIs have

due to a lack of expertise in one area or vastly different perspectives in one area vs. the other. In addition, this

would be very difficult for a typical panel from each program (NeTS or MES) to properly review this work, in part

research brings together background knowledge and domain understanding from two traditionally separate fields, it

curriculum that will empower future generations with new ways of thinking. Because the proposed interdisciplinary

in substantial ways. Broad dissemination of results through publications will expedite knowledge transfer within the

that can benefit from this research, including manufacturing, service, and information technology. New innovations

1

This CREATIV project aims to integrate expertise across the two traditionally separate disciplines of manufacturing

and networking in order to bring about transformative research that will have substantial impact in both communities.

This effort brings together the team of PI Dai from the manufacturing and operations research community and PI

Lin and PI Xu from the networking community to tackle the challenges set forth in this proposal. In particular, this

research will be driven concurrently by two distinct applications, one in advanced semiconductor manufacturing, and

the other in data center networking. Whereas previous work on wafer fab scheduling has largely focused on throughput

maximization and mean cycle time minimization, emerging business models in semiconductor manufacturing are

requiring foundries to provide delivery guarantees to customers. In networking, emerging warehouse-scale data centers

are virtualized to house many cloud computing applications simultaneously. These virtualized data centers employ

multipath routing architectures to alleviate communication bottlenecks and server load-balancing to enable the

scaling of distributed applications. In these environments, network performance guarantees are becoming essential.

A unifying framework for modeling and analyzing problems in both application domains is the stochastic

processing network model, which provides a powerful abstraction for a diverse range of real-world applications,

including manufacturing systems, service systems, communication networks, and computer systems. The central

contribution of this work will be a new mathematical foundation that we call Stochastic Processing Calculus that

will allow us to reason about and provide performance guarantees in stochastic processing networks. In particular,

we plan to investigate the problems of delivery guarantees in semiconductor manufacturing and network performance

guarantees in virtualized data centers as concurrent drivers in our research so that our investigations into the two

application domains can inform each other to bring about new solutions that might not be imagined otherwise.

Broader Impact: The broader impact of our proposed research lies in part in the diverse range of economic sectors

that can benefit from this research, including manufacturing, service, and information technology. New innovations

in any of these sectors will have enormous societal benefits by solving problems that can improve the quality of life

in substantial ways. Broad dissemination of results through publications will expedite knowledge transfer within the

academic community and between academia and industry. Research and education will be integrated through new

curriculum that will empower future generations with new ways of thinking. Because the proposed interdisciplinary

research brings together background knowledge and domain understanding from two traditionally separate fields, it

would be very difficult for a typical panel from each program (NeTS or MES) to properly review this work, in part

due to a lack of expertise in one area or vastly different perspectives in one area vs. the other. In addition, this

research is high-risk in nature because of the complexity of the abstraction models considered. Finally, the PIs have

no other current or pending proposals that deal with the subject matter described in this proposal.

CREATIV: Stochastic Processing Calculus: A New Methodology for Advanced Semiconductor Manufacturing and Data Center Networking

PIs: J. G. Dai (Georgia Tech), B. Lin (UCSD), J. Xu (Georgia Tech)

This CREATIV project aims to integrate expertise across the two traditionally separate disciplines of manufacturing

and networking in order to bring about transformative research that will have substantial impact in both communities.

As the manufacturing and networking communities have often in the past looked at problems from very different

perspectives, asking different questions, we believe this interdisciplinary research will lead us to raise new

fundamental questions and interesting new directions for research.

In additional to a unifying mathematical foundation, this research is potentially transformative in that it will

bring about new ways of thinking about problems in both communities. For example, our initial ideas on wafer

fab virtualization have been inspired by our insights into concepts from data center virtualization. Similarly, new

data center computation models share many similarities with manufacturing problems. We believe new ways of

thinking about data center problems will arise based on insights from the manufacturing field.

Broader Impact: The broader impact of our proposed research lies in part in the diverse range of economic sectors

that can benefit from this research, including manufacturing, service, and information technology. New innovations

in any of these sectors will have enormous societal benefits by solving problems that can improve the quality of life

in substantial ways. Broad dissemination of results through publications will expedite knowledge transfer within the

academic community and between academia and industry. Research and education will be integrated through new