November 11, 1992 First meeting of the Qmips Management Board

11h00 General discussion and Updating of the dates and the contents of the 1993 qmips workshops.

12h30 Lunch outside INRIA (November 11 is not a work day in France)

14h00 Updating of the list of deliverables (papers, proceedings, books, software), so as to have something substantial to show in November 1993.

16h00 Break

16h30 Discussion on reviewers and on the date of the first review. Data Base of the project publications, Format and plans for publications, Interaction with the commission. Any other topic.

17h30 End of the meeting

19h00 Management Board Dinner.

November 12, 1992 First Qmips Workshop

9h00 F. Baccelli Welcome, Qmips news

Scientific Program

Session 1: Formalisms - introductory talks

9h20-10h05	M. Silva (ZAR)	Petri nets, qualitative modelling, and untimed analysis techniques.
10h05-10h10	Pause	
10h10-10h55	G. Balbo (TOR)	Timing Petri nets to obtain performance models
10h55-11h00	Pause	
11h00-11h40	G. Chiola (TOR)	Petri nets and Queueing networks: similarities and differences
11h40-11h50	Pause	
11h50-12h50	F. Baccelli (INR)	Max-Plus representation of Stochastic Petri nets

13h00 Lunch at INRIA

Session 2: Computational Aspects

14h00-15h00	E. Gelenbe (EHE)	Petri-net primitives leading to product form
15h00-16h00	M. Siegel (UER)	On Efficient Markovian Modelling
16h00-16h30	Pause	
16h30-17h00	Z. Liu (INR)	Stochastic ordering of Event graphs, large deviation estimates
17h30-18h00	J. Campos (ZAR)	Distribution insensitive throughput bounds for timed Petri nets
18h00-18h30	M. Silva (ZAR)	Approximate analysis of stochastic Petri net subclasses

18h30 Pause

20h00 Workshop Dinner in Valbonne

November 13, 1992

Session 2 : Simulation, Software tools

9h00-9h40	A. Jean-Marie (INR)	SIMD simulation of stochastic event graphs on the Connection Machine
9h40-10h20	G. Chiola (TOR)	Distributed simulation of timed Petri nets
10h20-10h40	Pause	
10h40-11h20	G. Franceschinis (TOR)	Stochastic Well Formed nets
11h20-12h00	S. Donatelli (TOR)	Kronecker algebra and distributed state space analysis

12h00 Lunch at INRIA

Session 3: Planning of PN research during the first 15 months of Qmips

13h30 Planning of theoretical investigations

14h30 Planning and coordination of software developments

15h30 Technical exchanges. Information on industrial models

17h00 Closing of the meeting

ABSTRACTS OF PROPOSED TALKS

M. Silva *"Petri nets, qualitative modelling, and untimed analysis techniques"*

Petri nets constitute a formal model of complex concurrent systems. An outstanding aspect of Petri net models is their capacity for being analyzed to check if the constructed model verifies some specification properties. Among these, synchronic properties (lead, distance, places bounds, places mutual exclusions, etc.) and activity properties (deadlock-freeness, liveness, home states, etc.) can be studied. The first ones are, in temporal logic terminology, close to "safety properties", while the second group is close to so called "liveness properties". The qualitative analysis of net models is now a relatively mature field for place/transition nets. Several techniques based on reachability analysis, on reduction/transformation analysis, and on structural analysis of net models will be presented.

G. Balbo *"Timing Petri nets to obtain performance models"*

The introduction of time in the Petri net formalism can be done in many different ways. Different choices may produce timed models with completely different characteristics the one from the other. The application domains for these timed Petri net models and the analysis techniques to study them may also differ substantially. The objective of timed Petri nets within this project is to obtain a model somehow "similar" to queueing networks that can be used in cases where standard product-form queueing networks fail to be applicable. Moreover a time definition that is consistent with the qualitative behaviour of the original untimed Petri net model allows one to exploit qualitative analysis results for timed models. Different problems and choices will be presented and analyzed with respect to these two goals in order to clarify the type(s) of timed Petri net model we will use within QMIPS.

G. Chiola *"Petri nets and Queueing networks: similarities and differences"*

Timed Petri nets (TPNs) are made of a graph model that describes the logic behaviour of a system and an interpretation that defines its time semantics. By changing the trade-off between graph complexity and interpretation complexity the modelling power and features can be adapted to the needs of an application domain. On the one hand the constructive details of a system can be represented using the capabilities to describe discrete state systems (like finite state automata). On the other hand only the input/output flow relations may be represented (like queueing systems), abstracting from the implementation details. The choice of the best level of modelling detail for each component and the capability of representing interaction among components in net form is the key for a successful utilization of TPNs in problems that are not easily handled by queueing networks or Markov chains.

F. Baccelli *"Max-Plus representation of Stochastic Petri nets"*.

We review recent results on stochastic Petri nets based on the so called $(\max, +)$ approach. In this approach, the state variables of the network are the epochs at which transitions fire, to be opposed to the marking state variables of the conventional approach. We recall that, within this framework, stochastic event graphs can be seen as $(\max, +)$-linear systems in a random medium, and indicate how to translate the graphical description of the network into a standard $(\max, +)$-linear recurrence of order 1. We then review basic stability results and show their relations with the spectral theory of random $(\max, +)$-matrices. We show in particular that cycle times can be seen as $(max, +)$-Lyapunov exponents and stationary regimes as $(max, +)$-stochastic eigenvectors. We then show how this approach provides structural results on the throughput and the stationary marking processes.

M. Siegle This talk is a contribution to the modelling of parallel and distribut ed systems using Markovian models. Stochastic Petri nets, queueing networks, stochastic graphs or oher modelling paradigms can be used to specify the model. The combinatorial state space explosion problem resulting from the largeness and complexity of realistic models is addressed. Decomposition techniques have been suggested to overcome this problem. It is shown that the exploitation of model symmetries can reduce the model's state space dramatically. Symmetries may be defined implicitly by means of a structured model description (e.g. using Coloured Stochastic Petri Nets or hierarchical models), making it possible for analysis tools to take advantage of the symmetries automatically. In case of an unstructured model description, structural analysis of the model helps to identify constructs which can be simplified using transformation rules.

Z. Liu This paper focuses on various stochastic comparison problems arising in the analysis of Stochastic Decision Free Petri Nets (SDFPN). The analysis is based on the evolution equations satisfied by firing times. Various structural properties are obtained including the association of the firing times and their stochastic and convex monotonicity with respect to the timing sequences and to the initial marking. Various bounds for the asymptotic cycle time are then derived from these stochastic ordering results. In particular, we get an extension of the stochastic concavity result of Shantikumar and Meester to SDFPN's. This result holds true when the firing times are i.i.d and belong to a large class of log-concave distribution functions which is introduced in the paper. We also focus on the derivation of bounds and estimates for cycle times of strongly connected stochastic event graphs with i.i.d. holding times, and on basic optimization problems. We use association properties satisfied by partial sums of the holding times in order to prove that the firing epochs compare for stochastic ordering with the last birth in a multitype branching process, the structure of which is determined from the characteristics of the event graph using simple algebraic manipulations. Classical large deviation estimates are then used to compute the growth rate of this last birth epoch, following the method of Kingman and Biggins. The method allows one to derive a computable upper bound for the cycle time.

J. Campos *"Distribution insensitive throughput bounds for timed Petri nets"*

Some recent results on the performance bounds analysis of some stochastic Petri net systems are presented. In particular, upper and lower bounds for the throughput of transitions of Petri net systems can be efficiently computed for important net subclasses. The results are based on the knowledge of the net structure, the routing probabilities, and the mean values of the service time of transitions. In this sense the presented bounds are insensitive to the probability distributions of services. The computation is based on linear algebra, linear programming techniques, and classical laws from queueing theory. In all cases, we look for algorithms that can be executed with polynomial time complexity on the net size.

M. Silva *"Approximate analysis of stochastic Petri net subclasses"*

A new technique for an iterative approximate analysis of some stochastic Petri net subclasses is introduced. It is embedded in the divide and conquer paradigm. The basic idea leads to the notion of a cut to split the original net system into two parts. On a structural level, we compute the workload of the subnets and preserve their marking behaviour. For this purpose the results from qualitative theory of the considered net subclasses are taken into account. From the stochastic perspective, the throughput computation on aggregated subsystems uses a response time approximation. The generalization of the idea leads to multiple cuts, where single cuts can be applied recursively leading to a hierarchical decomposition (i.e., cuts are at different levels).

A. Jean-Marie A new parallel simulation method is proposed for the class of stochastic decision free Petri nets, that is amenable to an SIMD implementation. This method is based on the max, +-linear structure of recurrence equations that were established for this type of systems. Two variants are analyzed, the spatial and the temporal methods. The spatial method allows one to simulate large networks. The temporal method, which generalizes to Petri nets a method that was introduced for queues, is of more use for simulating systems for a long time interval. The emphasis is put on the spatial approach which is shown to provide a simple way of estimating both the cycle time and the statistics of the marking process. The theoretical parallel complexity of this algorithm is first investigated In particular, a few examples of practical interest are provided (blocking queues in tandem and a stochastic job shop model) for which the cost of simulating $O(NT)$ events of a net of size T is in $O(N \log T)$ with this parallel simulation method, while the classical sequential discrete event simulation is in $O(NT)$ at least. These theoretical considerations are confirmed by experimental results obtained from a prototype that was implemented on the Connection Machine.

G. Chiola *"Distributed simulation of timed Petri nets"*

Distributed simulation strategies (Time Warp, Pessimistic time-stamp propagation, etc.) were originally developed, implemented and tested for the application to queueing network models. Their application to Petri net models requires some adaption to take into account the possibility of conflicts among transitions. An approach is presented that avoids this problem by partitioning the net model in such a way that conflicts may only occur within one logical process. This choice, that requires a simple static preanalysis of the net structure, allows one to use known simulation protocols without modifications. Other considerations on the net structure may also be exploited to devise heuristics to partition a complex model in logical processes or to efficiently simulate its behaviour in order to increase the speed up with respect to sequential simulation. A simple example is used to illustrate the application of such heuristics and their possible impact on the simulation speedup.

G. Franceschinis *"Stochastic Well Formed nets"*

Well-Formed Petri Nets (WNs) belong to the class of High-Level Petri Nets. These formalisms have been proposed to provide a more expressive language to the PN modeler and thus reduce the size of models representing complex systems. Besides being a suitable formalism for modeling complex systems, WNs have also some interesting properties that allow us to exploit symmetries at the state space level. These properties can be exploited also when exponentially distributed stochastic timing is introduced in order to decrease the complexity of Stochastic WNs (SWNs) performance analysis. This presentation is an introduction of the formalism, its symmetry properties, and the associated analysis algorithms.

S. Donatelli *"Kronecker algebra and distributed state space analysis"*

A class of SPN called SSA (Superposed Stochastic Automata) is introduced. SSA nets are obtained from a set of component stochastic automata by superposition of transitions. The infinitesimal generator of an SSA can be automatically written as a Kronecker expression of the infinitesimal generators of the component stochastic automata. The particular form of the expression can be exploited to compute the steady state solution without having to even store the infinitesimal generator matrix explicitly. The method also allows for a parallel implementation, thus leading to a saving in both time and space.