Response from authors on revised version of the paper:

CASM-14-02-1903

K. Jensen and L.M. Kristensen: Coloured Petri Nets: A Graphical Language for Formal Modelling and Validation of Concurrent Systems”

We have now submitted the revised version of the paper.

Firstly, we would like to thank the reviewers for the careful work that they have done in reviewing the paper, and for the constructive comments provided on how the submitted paper could be improved. Before going into details on how we have addressed the comments of the reviewer, we find that it is appropriate with a discussion of the overall content of the review reports.

Reviewer 1 gives a very positive review of the paper and find that: “.. the paper can be published as is”. The primary issue raised is item 7 in the report on some references to other high-level formalisms and tools.

Reviewer 3 has also provided a positive review raising two main issues in the report. One issue is that more detail on the validation and verification part of the paper, and the second issue is references two other high-level formalisms, consistent with the main issue raised by reviewer 1.

Reviewers 3 has “mixed feelings” about the paper primarily on the basis of questioning whether the paper with the current focus on CPNs should be published in CACM, but basically leaves this decision to the editor taken into account the content of other review reports.

Below we explain in detail how we have addressed the comments provided in the three review reports. It should be note that there is a strict limit of 8 pages for manuscripts of CACM which has impacted which of the reviewers comments that we have been able to address, in particular those that asks for more material to be added to the paper.

**Reviewer 1:**

Report on „Coloured Petri Nets. A graphical Language for Formal Modeling and Validation of

Concurrent Systems“ submitted by Kurt Jensen et al to CACM. Manuscript ID CASM-14-02-1903

The paper is technically sound and professionally interesting. The paper presents an adequate

picture of the “Coloured Petri Nets” modeling technique. This technique is of interests for many

readers of the CACM. The paper meets the requirements of the author guidelines of the CACM for

contributed articles. Summing up, the paper can be published as it is.

I nevertheless see chances for improvement. The authors may consider the following

recommendations; I do however not require them to be followed necessarily.

>1. page 1, column2, line 36 (I follow the numbering on the margin): Here and at some other places you >use “Petri nets” with singular “is”, as a generic term. This is a matter of taste; however, in

>line 45 “Petri nets (plural) … is a graph (singular)”, This principle is very confusing. Furthermore,

>you sometime use “Petri nets” with plural. Be consistent!

**TODO**

>2. page 1, column 2, line 58: “conflict” is not for the general audience. Add “non determinism” in

>brackets.

**TODO**

>3. page 2, column 2, line 25: Motivate the term “substitution”. For readers with some familiarity

>with Petri nets it would be convenient here to understand that the firing rule is not applicable

>here.

**TODO**

>4. A general remark to the graphics: All Figures follow the rules of the CPN-tools. But this article

>would be more readable if you just skip some redundancy. Figure 1: “coordinator” is written

>inside as well as on the edge of the left box. Likewise, “workers” at the right box. Figure 3: The

>token ( ) is mentioned three times: As the type of the place, as the actual token load, and as the

>number of actual tokens. His confuses newcomers a lot. Generally, in your entire example, the

>“multiset” aspect is irrelevant. You never have two or more identical tokens. So just skip

>multiplicities everywhere. Furthermore, the “Out” and “In” information at the places in the right

>column of Figure 3 is anyway given by the arrow heads. Skip the small boxes and the

>corresponding text. For the newcomer, this is just boring and confusing.

**TODO**

>page 4, Figure 4: The place *Can commit* carries the circled “2” on the margin, whereas “Waiting

>Votes” carries the corresponding “1” inside. Many Figures are inconsistent this way.

**TODO**

>5. page 5/6, Sect. 3: The relation to P/T nets is valid. But there have been many more wellmotivated

>proposals for unfoldings and for high-level nets.

**TODO**

>6. page 7, column 2, line 41/42: “…. properties expressed using …” is no good English style.

**TODO**

>7. It’s good scientific praxis to also discuss the limits of one’s achievements. For example, Petri nets

>offer a whole bunch of analysis methods (Place invariants, transition invariants, traps,

>coverability graphs, …), supported by other tools, and lifted to high-level versions of Petri nets.

>You should shortly mention this. Likewise, the state explosion problem, that you frequently

>mention, has successfully been attached for Petri nets, by exploiting symmetries, reversibility,

>etc. Finally, there are other, successful Petri net based industrial software tools. It is more

>impressive for the audiences to present CPN-tools as “the flagship among many” than presenting

>them as solitaire.

**Reviewer 2:**

Referee report on the paper CACM -14-2-1903

**Coloured Petri Nets: A Graphical Language for Formal**

**Modeling and Validation of Concurrent Systems**

>I have mixed feeling about this paper.

**>Pros:**

>The paper is well written and a pleasant reading at least for the readers who appreciate this type of >contributions. (Apart from a few minor but not irrelevant issues pointed out below). Colored Petri Nets >(CPNs) are certainly a major contribution in the field of modeling concurrent systems, with particular >reference to the models rooted in the original Petri’s work. In the decades they evolved effectively in >terms of modeling features, supporting tools, and applications to practical problems.

Many thanks for the positive comments.

**>Cons:**

>CPNs have been around for quite a while and many papers in the open literature already document >all

>aspects –and history- of this formalism; there is even a full, rather recent, Springer monograph >authored by the same authors of this paper. CPNs are certainly not the only formalism that >addresses the issue of modeling and analyzing concurrent systems; neither are they the only general >extension of the original Petri’s model; the authors properly point out that many of such extensions >were ad-hoc, but there are others that are as general and well thought as CPNs, such as, e.g., CO->OPN, or the now numerous UML-based formalisms, i.e. those formalisms that starting from UML >*notations* enrich them with various form of formal semantics; notice, BTW, that some UML >notations are clearly inspired by Petri nets.

TODO (more discussion of other high-level nets formalisms)

>So, my main question is: should CACM publish a paper which certainly address an important issue >and describes *just one* among many proposed approaches, all already well documented and >illustrated in the open literature?

>Given that we do not expect original results from such a paper, which type of CACM readers could >be attracted and could obtain an added value from this paper? Certainly not readers who already >know about CPNs; also readers who are already in the field of modeling concurrent systems most >likely would be aware of the many existing approaches, and, even if not knowing the special >contribution of CPNs would not find any difficulty in reaching the abundant and widely accessible >documentation. Many readers are probably aware of the increasing relevance of concurrent and >distributed systems and could be interested in a quick but not trivial understanding of the problem >and of the solutions offered by the state of the art. For this type of readers, however, I think a broader >paper would be more useful: even assuming to give a privileged focus on CPNs, and avoiding the >style of a typical Computing Surveys paper, I would favor a better statement of the critical issues in >concurrency (and real-time!), a kind of progressive “zoom-in” from general formal approaches, to >Petri nets-based ones and, finally to CPN. This would probably make an already long paper (for >CACM) a little longer, but some space could be saved by giving up a few “historical remarks” about >CPNs and some details about the rather standard tool interface.

We find that the broader paper requested here would be a very different paper from what we have submitted. Hence, we have not attempted to revise the paper to make it a more general paper on formal modelling languages for concurrent and distributed systems. In particular, since we find that there are other researchers in the community of formal methods that would be in a much better position and have more credibility in writing such a paper. Our intention with the present paper was to make the CPN language visible to a broader computing community than what one normally reaches with textbooks and with papers published at formal methods oriented conferences. It seems that CACM publishes such papers. A recent example is in Vol. X of CAMC, 2014 in which there is a paper on the Scala programming languages for which there also exists numerous published papers and textbooks. Hence, we find that the paper serves a difference purpose than already published material. Furthermore, given the two other positive review we decided to not fundamentally change the content of the paper. We agree that in the end this is basically an editorial decision to be made.

>On the basis of these remarks I am rather against publishing this paper, with all respect and >appreciation for the authors and their long standing research. However, since it is not easy for me to >“impersonate” the average CACM reader, I would certainly not object if the editor, possibly on the >basis of a different report, decides to overwhelm my opinion.

See our response to the previous item.

>In case the paper is accepted for publication, here are a few minor but not irrelevant points, besides >the above general remarks.

>1. On the basis of the hypothesis that this paper should attract and be well-understood by general

>readers, I would recommend to expand considerably the sidebar about basic PNs, including some

>discussion on their ability to capture problems such as deadlock, conflicts, and their limitations so

>that it will be later clear where are the advances introduced by CPNs (presently such general

>comments are scattered within the CPN presentation).

TODO

>2. From a theoretical point of view the authors state that CPN “do not add expressive power” to basic

>PTNs; but properly add “(possibly infinite)”. This is due to the unfolding process; however, infinite

*>processes* are not exactly *abstract machines*, rather, roughly speaking, they represent *machine*

*>behaviors*. In fact, whereas original (finite but unbounded) PNs have not the power of Turing

>machines, many forms of extended PNs, including CPNs which can simulate, e.g. PNs with inhibitor

>arcs, do have such a power.

TODO

>3. The above point has a natural impact when dealing with tools supporting the analysis of the model.

>Whereas a simulator can clearly produce *sample* behaviors of the modeled system even if the

>abstract machine is undecidable, a model checker can recursively state system properties only for

>decidable formalisms. I understand that it is now common practice to use model checkers to >“semidecide”

>properties of models which in principle are undecidable; this can be done in several ways:

>either by accepting the risk of non-termination of the tool, or by restricting the state space, or etc.…;

>it would be better, however, that the choices taken when applying tools to “in-principle->undecidableproblems”

>are clearly and explicitly stated. In this case the authors only speak about state explosion,

>i.e., complexity, but do they assume *a priori* some hypotheses that guarantee decidability (typically a

>finite state space, such as bounded number of tokens and finite domains for colors, as it happens in

>the paper’s example)? Or, is it the user who has the responsibility to write graphs whose properties

>are decidable? Or again, is the user who must choose and use the appropriate tool depending on

>the system she is modeling and the properties she wants to analyze? All this should be clarified,

>mainly for users who might not be theoretically well equipped.

TODO

>4. The issue of dealing with timing aspects is briefly touched at the end of section 2 but leaves >several

>unanswered questions, for instance: “The time stamp of a token specifies the earliest model time at

>which the token can be removed by the occurrence of a transition” seems to hint at a weak time

>semantics; in this case is it possible for the user to specify a timeout? Again, a considerable amount

>of literature on dealing with time critical aspects in Petri nets is ignored. If the intricacies of the

>timing semantics require going too deep into the issue, it is perhaps better to ignore it at all.

TODO

>5. The value (color) of the tokens is stated by the firing of the transition that produces the token; >this

>is consistent with the general philosophy of PNs. However, in the example *it seems* that in some

>cases such a value is completely specified by the label of the output arc, e.g. SendCanCommit

>produces exactly two tokens with the two colors; in the case of ReceiveCanCommit, instead the

>production of the pair (w, vote) is a little less clear: I would *guess* that there is a nondeterministic

>choice between Yes and No about the vote, which is produced by the transition firing, whereas the

>value of w is the same as the one received from the input token. Later, we read that the tool, in the

>automatic simulation applies random choices whenever the behavior is not determined –which is

>typical of PNs-; but random choices can rarely be useful to analyze properties such as reachability

>or safety, i.e. questions existentially or universally quantified w.r.t. possible behavior. This could be

>a nice complementary use between interactive, automatic simulation (which should however

>include some statistical analysis) and model checking; but it should be clearly explained to the >nonspecialized

>reader.

>6. Neither Firefox nor Explorer have been able to compile the full example in http:// goo.gl/HY4ZNQ

>which is redirected to http://home.hib.no/ansatte/lmkr/cpncommitprotocol.xml: Firefox reported

>“the XML file has no associated style sheet”.

**TODO**

>7. At p.7, r. 29, II column: constributed ---> contributed.

**TODO**

**Reviewer 3:**

>Comments to the Author

>This article introduces the well-established formalism of Colored Petri Nets (CPNs), and the two >authors are eminently qualified to write it, as they are some of the most important contributors to >the definition, development, and use of CPNs.

>The article succeeds in not being overly technical, while providing a fairly clear introduction to the >key concepts of CPNs. In particular, the modularity and the type-enforcing/checking features of >CPNs are gently introduced through the running example.

>I believe that an introductory article on CPNs to “wet the appetite” of CACM readers is appropriate, >and this submission might just do that. In other words, interested readers could then read more in >depth about CPNs through longer articles or even books (and multi-volume books like the one >authored by K. Jensen), and proper pointers to these publications are given in the references.

>Many thanks for the positive feedback.

>However, I have important two criticisms to the article:

>The first criticism is that, while the article does a good job of giving an idea of why CPNs might be a >good “language for formal modeling of concurrent systems”, it does not go into enough detail into >the types of techniques that can be employed for the “validation” (or is it “verification”?) of such >systems.

>The paper is thus unbalanced in my opinion, and it left me wanting more on the, let’s call it, >“analysis” part. I believe that this aspect is fixable by adding some more material. Ideally, it would >be good to refer the techniques to the running example, in the form: “if the user is interested in >analyzing X, techniques A, B, or C can be used, with the following tradeoffs…”, for a few X’s.

TODO

>The second criticism is that the authors have not compared CPNs to other related formalisms, >including other high-level formalisms related to Petri Nets, such as well-formed nets. The article >reads like CPNs (and the tools described for it) are the only game in town, while they are not. This is >understandable as the authors have been extremely involved with CPNs for most of their career, >but I still would have liked to see other alternatives mentioned.

>On the other hand, this strict focus on CPNs is perhaps acceptable for a CACM submission, as I >imagine the goal is to popularize a notion (the use of CPNs in this case), rather than to have a survey >of the entire field.

>In conclusion, I think that my first criticism should be addressed, but I leave it to the Editor to decide >whether the second criticism needs to be addressed as well.

>Regarding the writing, I have only a few minor editing suggestions:

>CPN Tools which => CPN Tools, which

>distributed system was => distributed systems were nets) that were introduced => nets), which were introduced

>Petri nets is => Petri nets are

>and is still able => and are still able

>is a directed bi-partite => are a directed bi-partite

>“staggering” is the wrong word, if you mean “slowing down”

>“zoo” is too informal a word, “variety” might be better

>is comprised of => is composed of

>in Fig 6 is => in Fig 6 are

>cannot without exchanging messages know the vote of another worker => cannot know the vote of >another worker without exchanging messages

>Above => So far,

>[19] that => [19], which

>It is based => This is based

>The sentence “and the model stays at the current model time until no more transitions are >enabled” is unclear to me, I did not understand what you mean.

>10.000 => 10,000 (but it might depend on CACM typesetting standards)

>got the idea => had the idea

>Are sidebar II and III called in the main text? If not, they should be.

>The sentence “Many advanced techniques exist to combat the state explosion problem, and most of >these can be applied also in the context of CPN models” is vague:

>what techniques are actually available in CPN tools? I would like more details.

>The research into => Research into