

A Generic Framework for Hybrid Simulation in Complex Systems: A Healthcare Example

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Introduction

This research proposes a generic framework for hybrid simulation for complex service systems. It has been argued that a hybrid approach, wherein system dynamics and discrete event simulation are integrated symbiotically, will provide more realistic picture of complex systems. The proposed framework is evaluated empirically with a healthcare case study.

Background

- Healthcare is an example of complex service systems: it exhibit both detail as well as dynamic complexity.
- In order to make effective decisions, tools are required for comprehending complexity.
- Two simulation techniques, discrete event simulation and system dynamics have become quite popular in the healthcare domain
- Due to its holistic perspective and focus on non- linearity, SD lends it self smoothly to capture dynamic complexity.
- DES due to its focus on detail is ideal for capturing detail complexity.
- SD and DES are not capable of comprehending both detail and dynamic complexity.
- It has been argued that hybrid simulation (integrated deployment of SD and DES) has potential to comprehend both detail as well as dynamic complexity.

Need for Generic theoretical Frameworks

- The need and appetite for hybrid simulation in the healthcare domain has been documented.
- As Hybrid simulation is a form of mixing methods, due to fundamental differences mixing of methods is difficult. Hence mixing of methods require theoretical frameworks for providing guidance (Mingers, (1997))
- Quite a few technical frameworks have been proposed (Vekateswaran et al, (2005); Helal et al, (2007) ; Avalanchi et al, (2010))
- Currently, there is no conceptual framework which provides guidance on integration of SD and DES to form hybrid models.

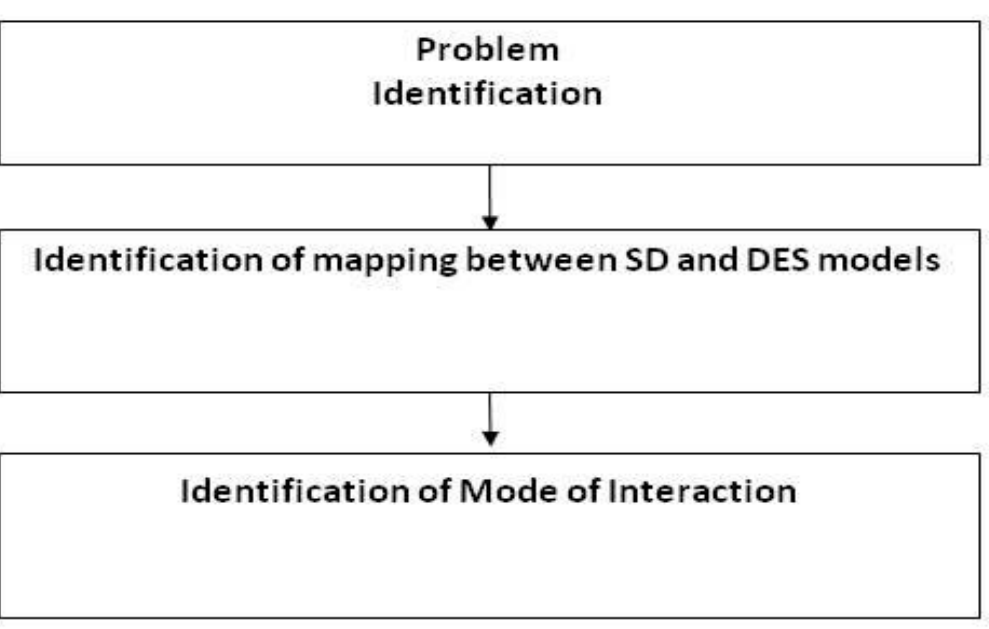
Requirements of the Framework

Requirements provide the basis for evaluation of conceptual frameworks. On the basis of knowledge induced from literature, three requirements for the generic framework have been established.

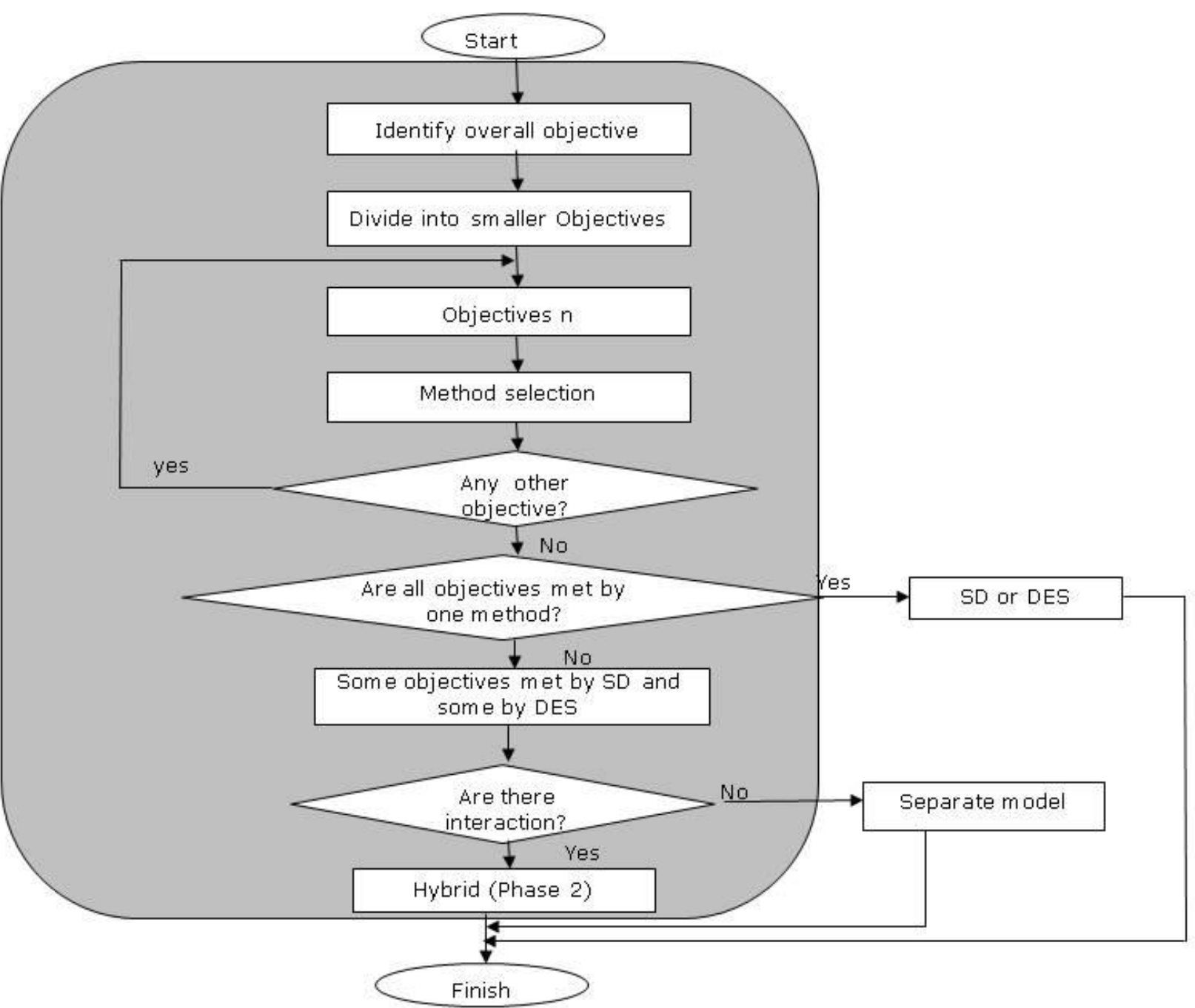
- Why Hybrid simulation?**
Justification for hybrid simulation
- What is exchanged?**
Mapping between SD and DES models
- How it is Exchanged?**
Interactions between SD and DES models.

The Proposed Framework

In order to address these requirements, the proposed framework was based on three phases. Each phase of the framework provides guidelines for addressing a specific requirement.

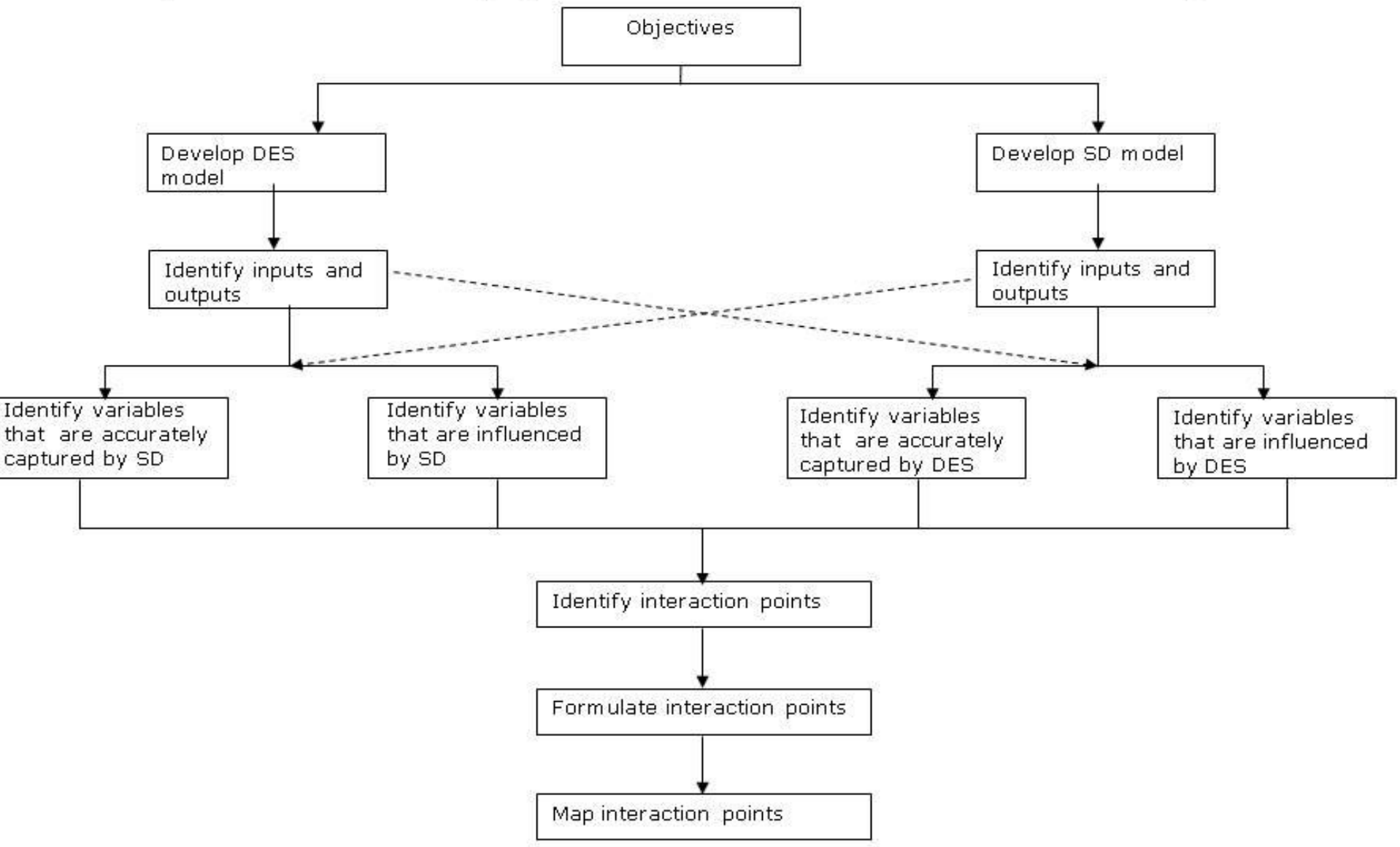


Phase1: identification of problems



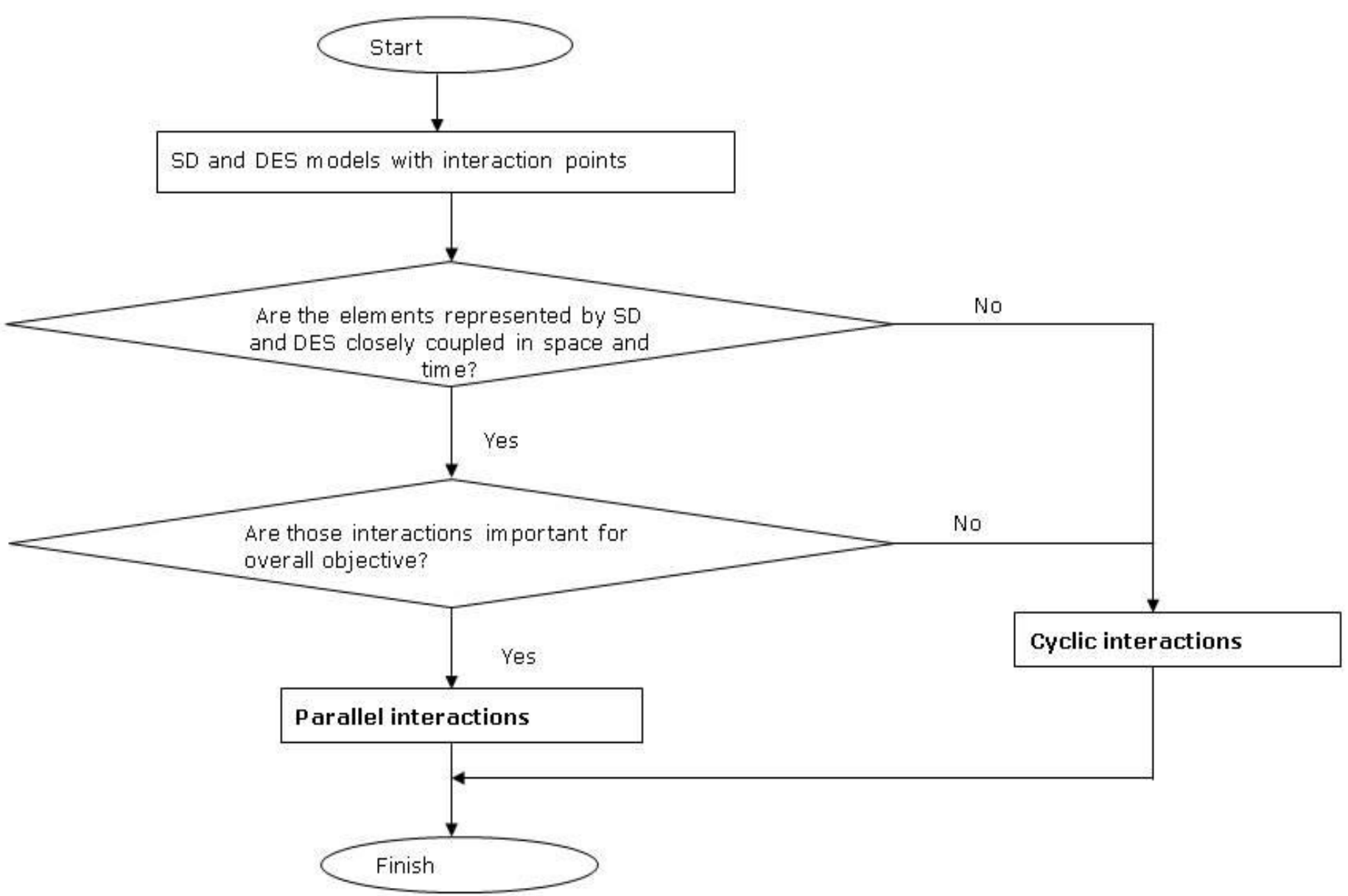
Phase 2: Mapping between SD and DES models

In this research Interaction points are defined as variables whose values are replaced or influenced by variables from the other model and variables that replace or influence the values of variables of other models during hybrid simulation are named as "interaction points".



Phase3: Identify mode of interaction

Mode of interaction implies the way SD and DES models interact with each other over the time to exchange information during hybrid simulation.



Application of the framework

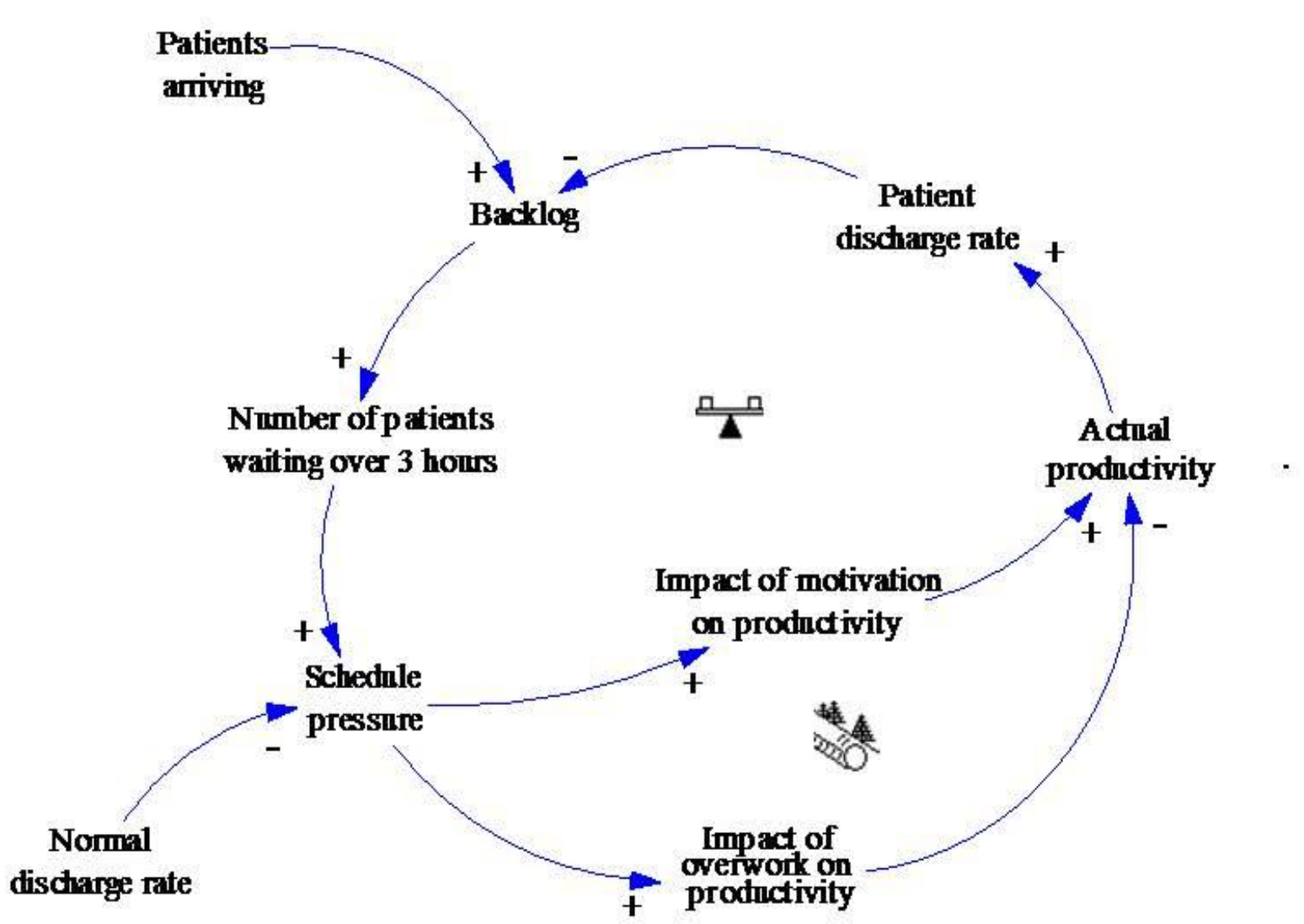
Overall objective of the problem

The indicators of performance of accident and emergency (A&E) departments in united kingdom are throughput, time-in-system and number of breaches. Breaches represent number of people who fail to meet the 4-hour target. The main objective of this study was to capture the impact of implementing an electronic white-board on A&E breaches

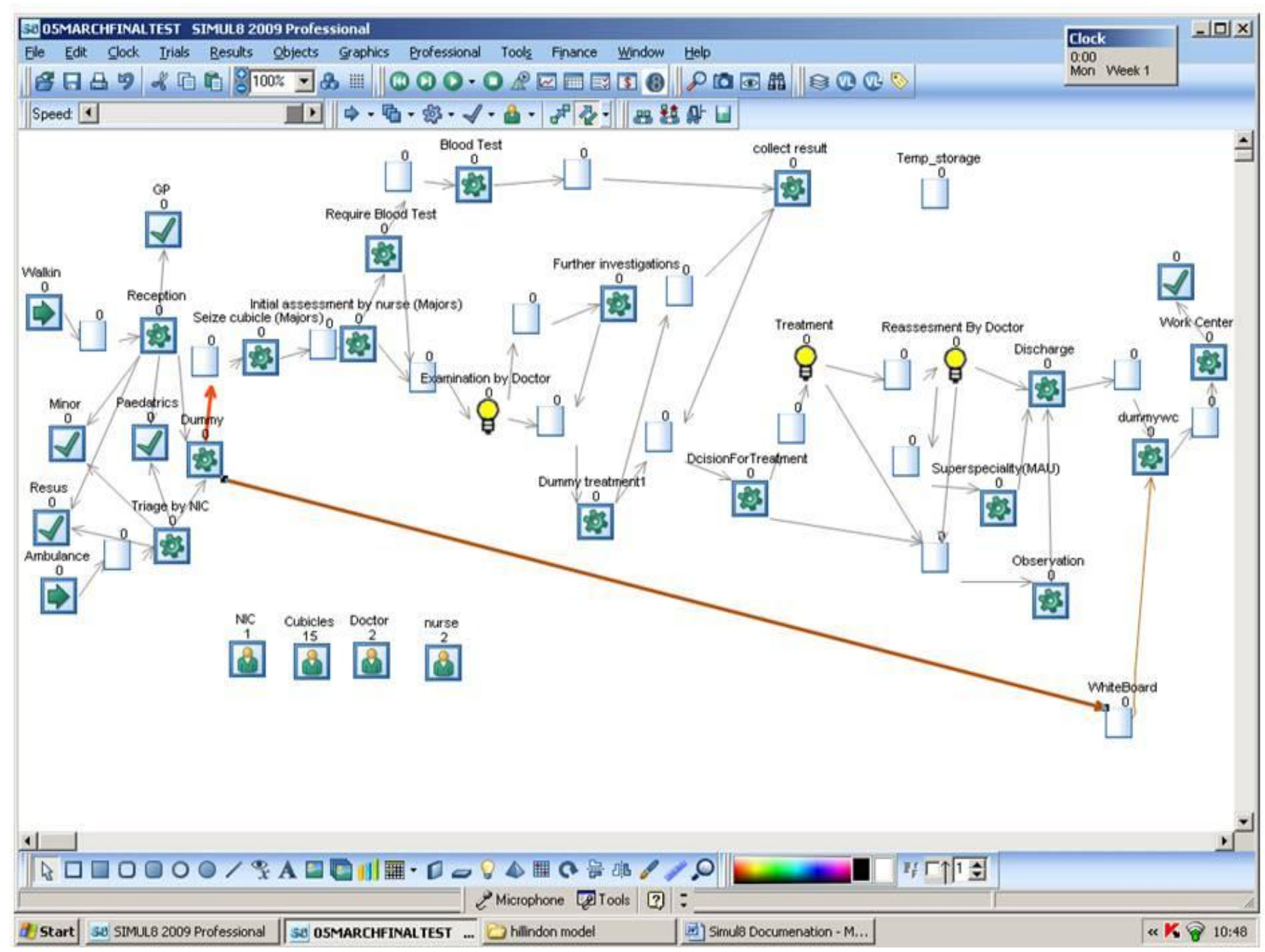
Decomposition into sub objectives

- Capture the variation in physician's productivity (which is affected by variables such as schedule pressure, backlog etc)
- Capture total time each patient spends in A&E department.
- Method Selection
 - Hybrid Simulation
 - SD for capturing variation
 - DES for capturing total time in A&E

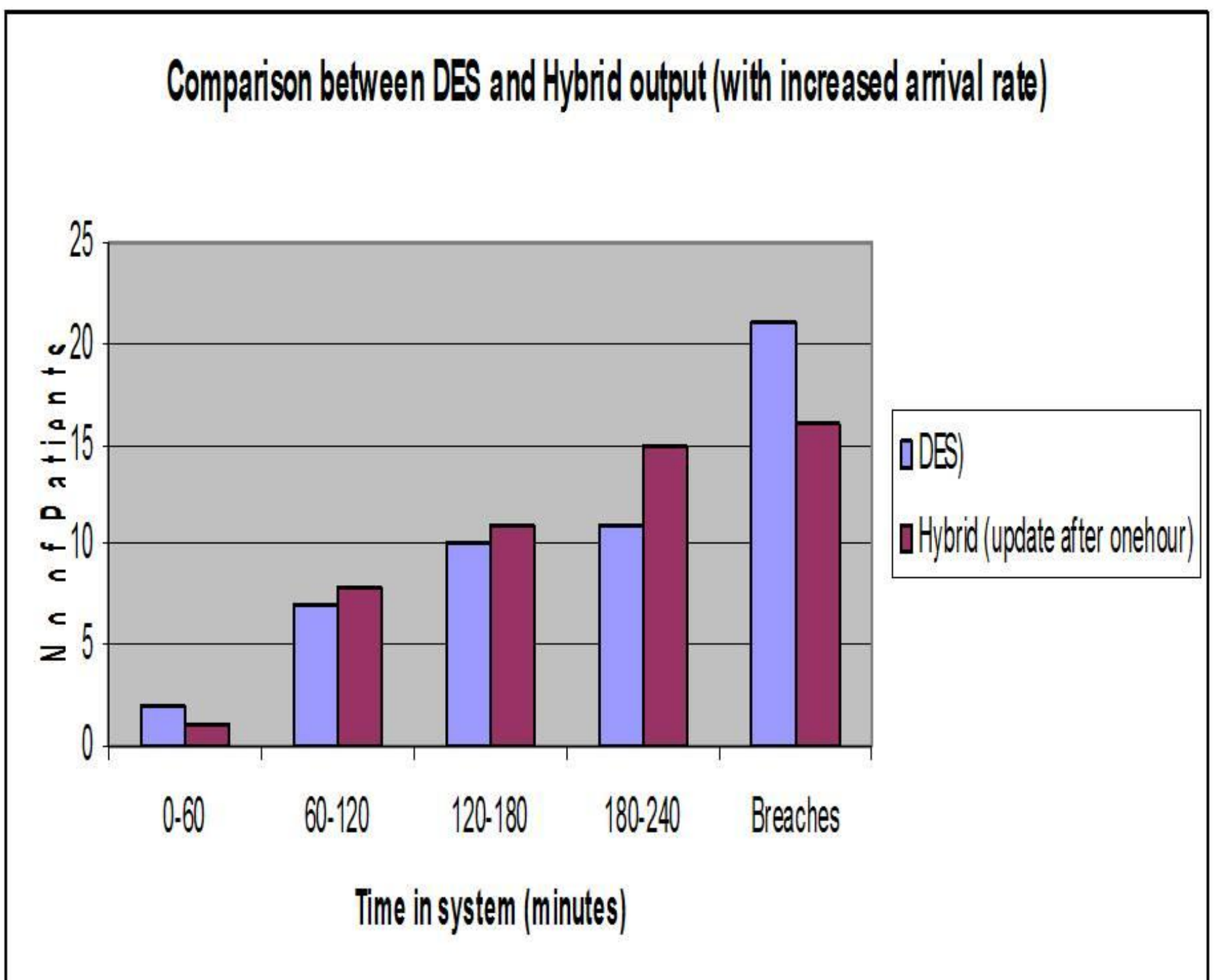
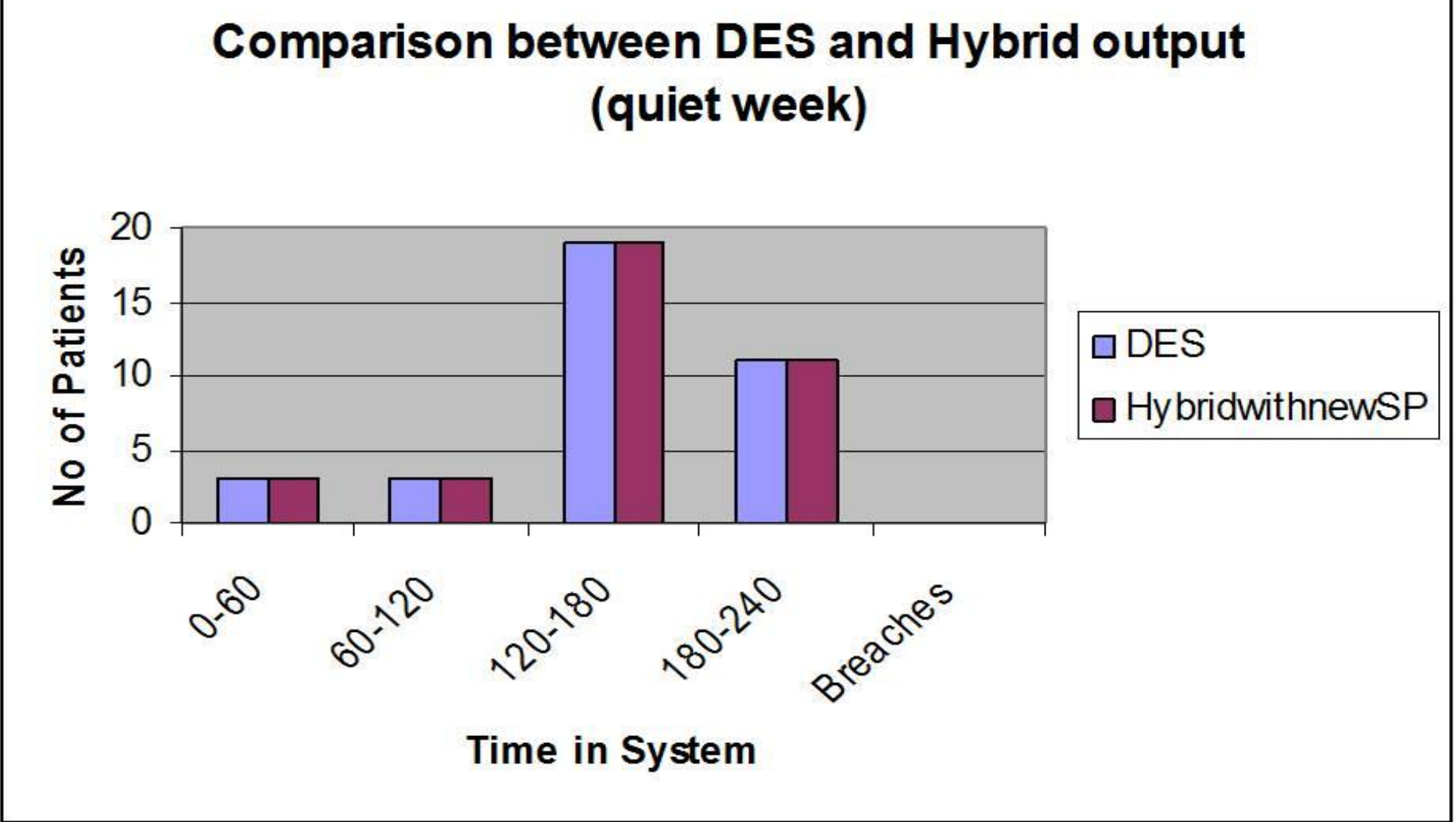
Overview of SD Model



Overview of DES Model

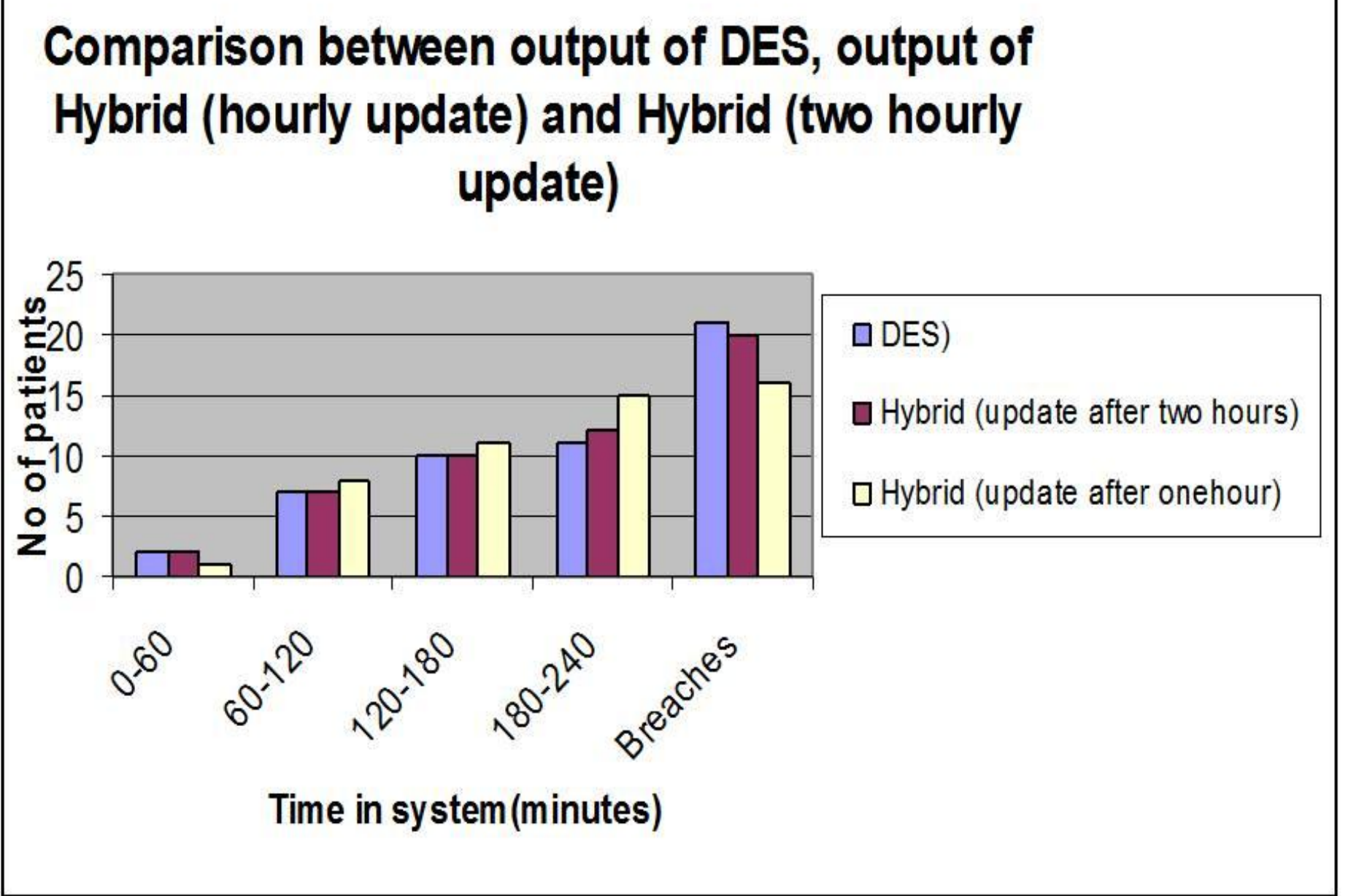
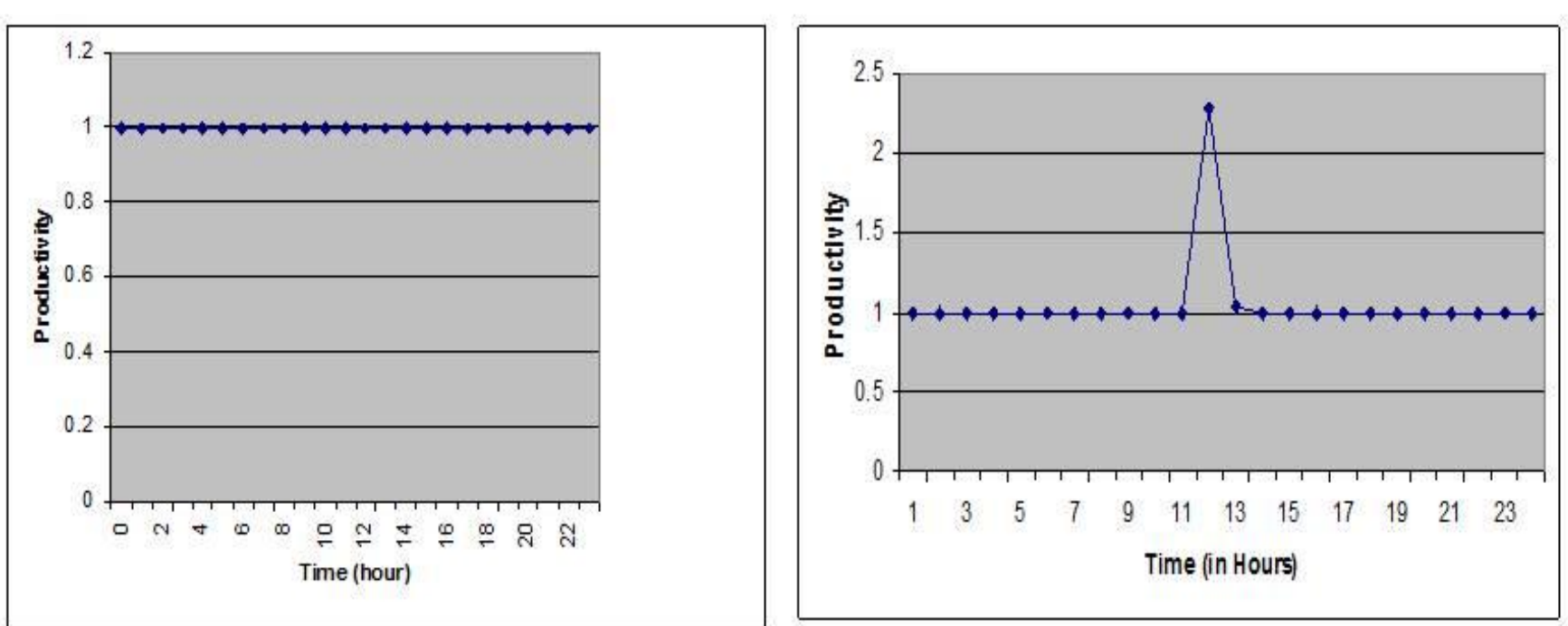


Results



productivity graph of DES (left hand side)
Productivity graph of SD (Right hand side)

In complex service systems, due to adrenalin factors productivity is fluctuating.



Conclusions

- Hybrid simulation capable of capturing feedback between detail and dynamic complexity.
- Hybrid simulation shows potential to capture the impact of intangible qualitative factors on tangible process performance.
- Hybrid simulation can provide more insight with less complexity.
- It is expected that this research will encourage those engaged in simulation (e.g., researchers, practitioners, decision makers) to realise the potential of cross-fertilisation of the two simulation paradigms.

Limitations and Future work

- Restriction of the framework to SD and DES only, has been highlighted as one of the limitations.
- Agent based simulation is another emerging approach for modelling dynamic behaviour of complex systems. Inclusion of agent based simulation into the framework will strengthen the proposed framework.]
- This research does not provide guidance with regards to automation of exchange of information between SD and DES.
- we are currently working on inclusion of agent based simulation in the framework and automation of exchange of information between SD and DES.

References

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Acknowledgement

This study is supported by Multidisciplinary Assessment of Technology Centre for Healthcare (MATCH), which is funded by ESPRC Grant GR/S29874/01.

