HSOR NEWS
The evidence behind your decisions
Health Services & Outcomes Research, **Issue 2009/4**

Variability in health care processes – the use of Discrete Event Simulation

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Discrete Event Simulation (DES) is a tool for studying the impact of variability and resource bottlenecks, and for scenario evaluation of proposed processes. It is widely used across industries to simulate complex processes and provide insights into possible outcomes. It allows decision makers to test a variety of "what-if" scenarios and evaluate the variety of outcomes before implementing costly changes. Such a study typically focuses on the modelling of queues, inventories and capacity using one of several commercial and open source DES software (Simul8, Arena, MATLAB SimEvents, Witness and Plant Simulation).

Applications of DES in healthcare

Healthcare system has complex processes with significant variability. DES is well suited to study these processes and explore potential approaches that achieve efficient workflow and resource utilization. Areas of its applications in healthcare include:

- Outpatient appointment scheduling
- Facility layout and capacity planning
- Bed planning
- Manpower planning
- Workflow and process evaluation

Case study: SOC appointment scheduling improvement in a NUH clinic

Questions:

1. Is it possible to reduce patient queue/waiting time and doctor overtime in SOC without introducing extra resource?
2. What is the appropriate number of planned appointments in one session?

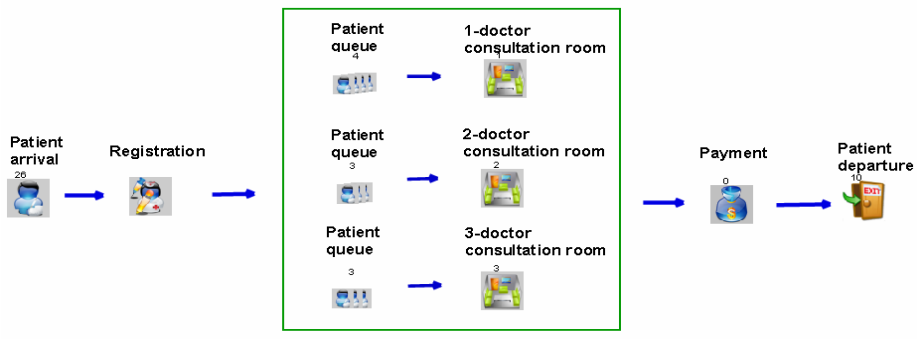

Fig. 1: DES model of NUH clinic

How it was done

A DES model using *Simul8 2008 Professional* was built to simulate current workflow (*Fig. 1*) and identify causes for the long patient waiting time and doctor's overtime.

- *Settings*: Three types of consultation rooms: 1-doctor, 2-doctor and 3-doctor consultation rooms.
- *Key performance indicators*: patient queue, patient waiting time, doctor's utilisation and his/her overtime.
- *Uncertainties*: variability in consultation time, patient arrival time and no-show rates.

The DES model identified two problems causing long patient waiting time and doctor overtime:

1. uneven distribution of appointment slots over the session and
2. workload imbalance among different sessions.

New appointment schedules were tested in the model and the simulation results were used to evaluate their performance. Significant improvements could be achieved in patient queue, waiting time and doctor overtime (*Figs. 2-3*).

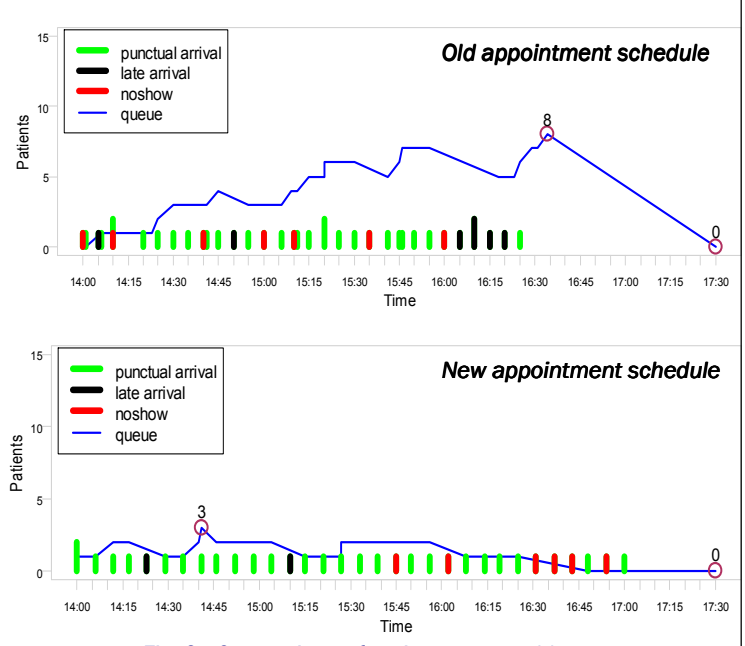

Fig. 2: Comparison of patient queue, old vs new appointment schedule

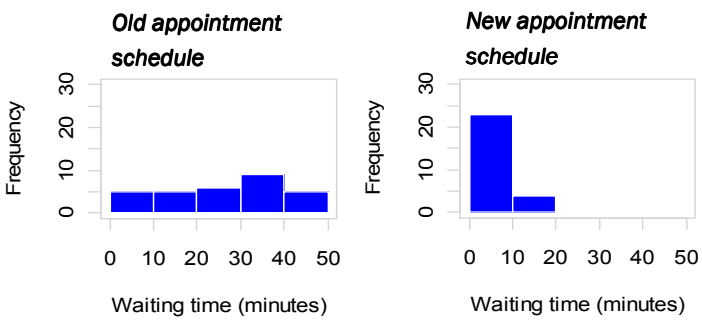

Fig. 3: Comparison of patient waiting time, old vs new appointment schedule

Trials	Number of planned appointments		50th %tile waiting time (mins)		95th %tile waiting time (mins)		Overtime (mins)	
	Old	New	Old	New	Old	New	Old	New
Trial 1 (1-dr clinic)	30	18	72	32	138	73	101	42
Trial 2 (1-dr clinic)	25	16	52	1	141	41	95	23
Trial 3 (2-dr clinic)	20	21	42	10	63	50	50	28
Trial 4 (2-dr clinic)	24	22	51	15	81	57	28	15
Trial 5 (3-dr clinic)	66	60	26	20	74	50	46	15
Trial 6 (3-dr clinic)	57	40	14	0	85	25	0	0

Table 1: Comparison of performance indicators in 6 actual trial runs, old vs new appointment schedule

So What?

Motivated by the results of the simulation, new appointment schedules based on the simulation results were proposed and trial sessions were carried out in the selected consultation rooms with the significantly improvements (*Table 1*).

Conclusion

DES is promising in modelling and analysing complex processes and workflows in healthcare system. Uncertainties can be easily incorporated in the DES models for accurate description of the actual situations. DES is flexible enough to model different processes by modifying the simulation parameters. The simulation results of DES help decision makers evaluate different alternatives and outcomes more efficiently.

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Zhu Zhecheng is an Operations Research Specialist in HSOR. His research interests are in applied optimization and discrete event simulation. He is involved in several healthcare projects including SOC appointment scheduling, bed partitioning for infection control, satellite pharmacy planning in our NHG institutions.