CLAHRC Wessex

Collaboration for Leadership in Applied Health Research and Care

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Arguments for and against the use of multiple comparison control in stochastic simulation studies

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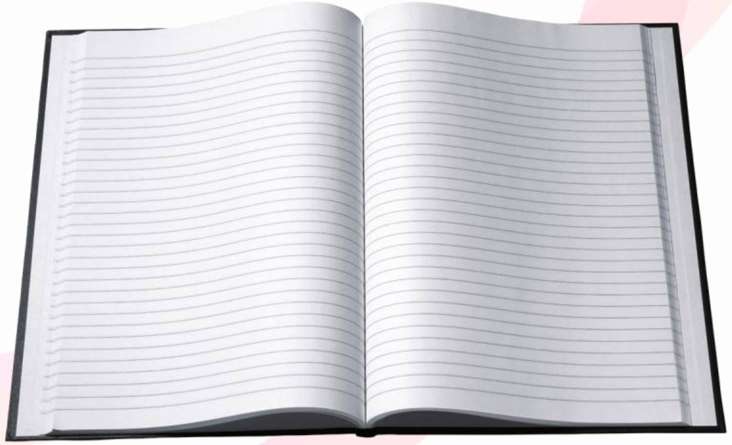
Motivation

- Pick up any standard Discrete Event Simulation (DES) text book and turn to the section on comparing scenarios



- They all talk about the Multiple Comparison Problem (MCP).
- But is a real issue in stochastic simulation studies?

What is the MCP? (1)

- It's about making mistakes in stochastic simulation studies!

- Mistakes in identifying differences between performance measures in competing configurations (scenarios) of a model when there are several or many alternatives to compare simultaneously

- Frequentist terminology: Type I or II error in inference.

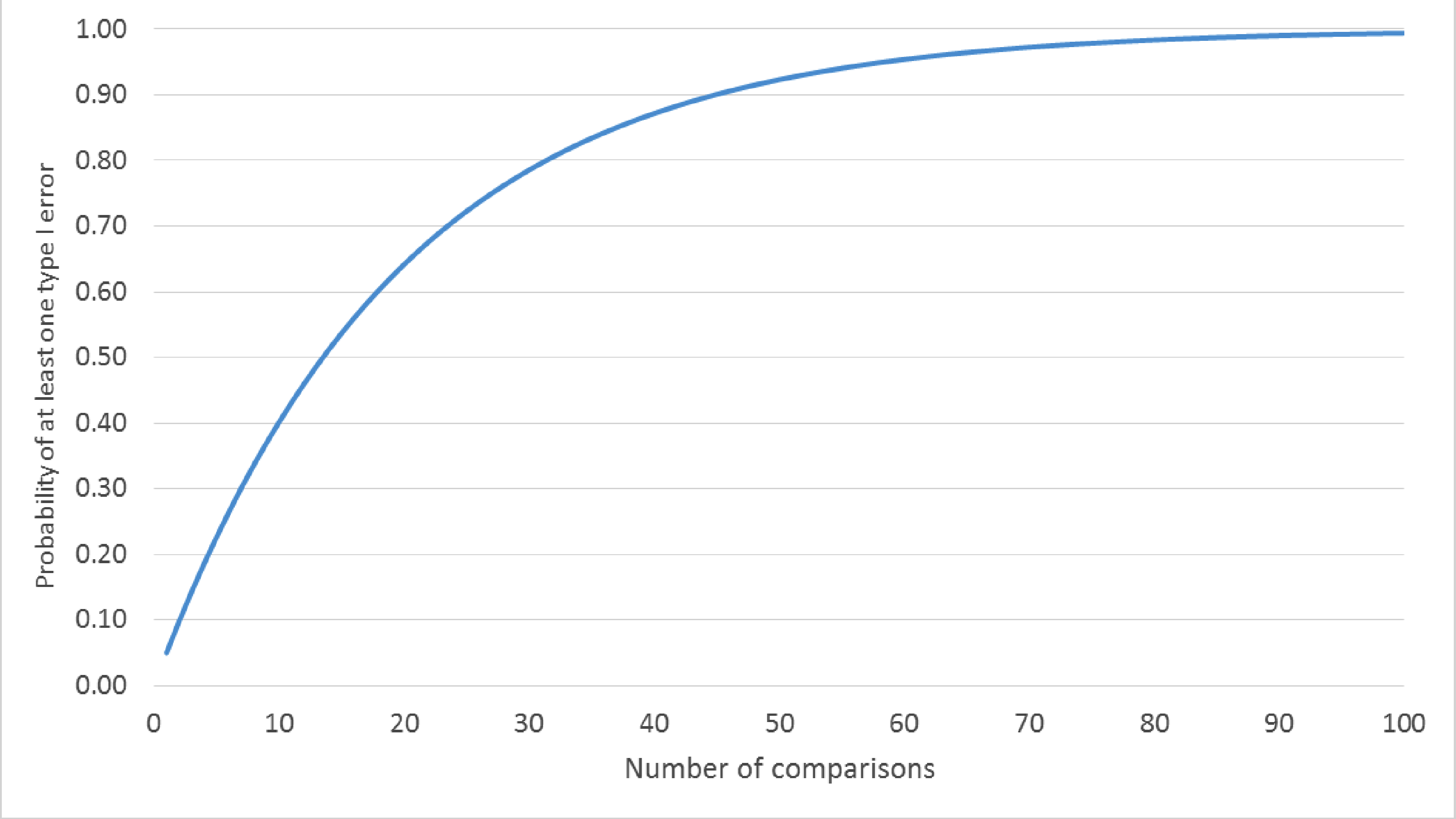
What is the MCP? (2)

- Two types of error rate
  - Per comparison error (e.g. 95% CI for scenario 1 versus scenario 2)
  - Overall experiment-wise error rate.

- We call the latter the **family-wise error rate (FWER)**
  - It is the probability of making a single Type I error in **m** comparisons

- When you conduct a large number of simultaneous comparisons the FWER inflates dramatically.

FWER Inflation



Alpha = 0.05.

Introducing Multiple Comparison Control (MCC)

- To tackle the MCP a number of MCC procedures have been developed.

- The most common MCC advocated in DES is the *Bonferroni Correction*.
  - This controls the FWER by creating stricter per comparison intervals.

- There are many alternatives, but in general the majority try to control FWER.
  - (we will introduce an alternative later).

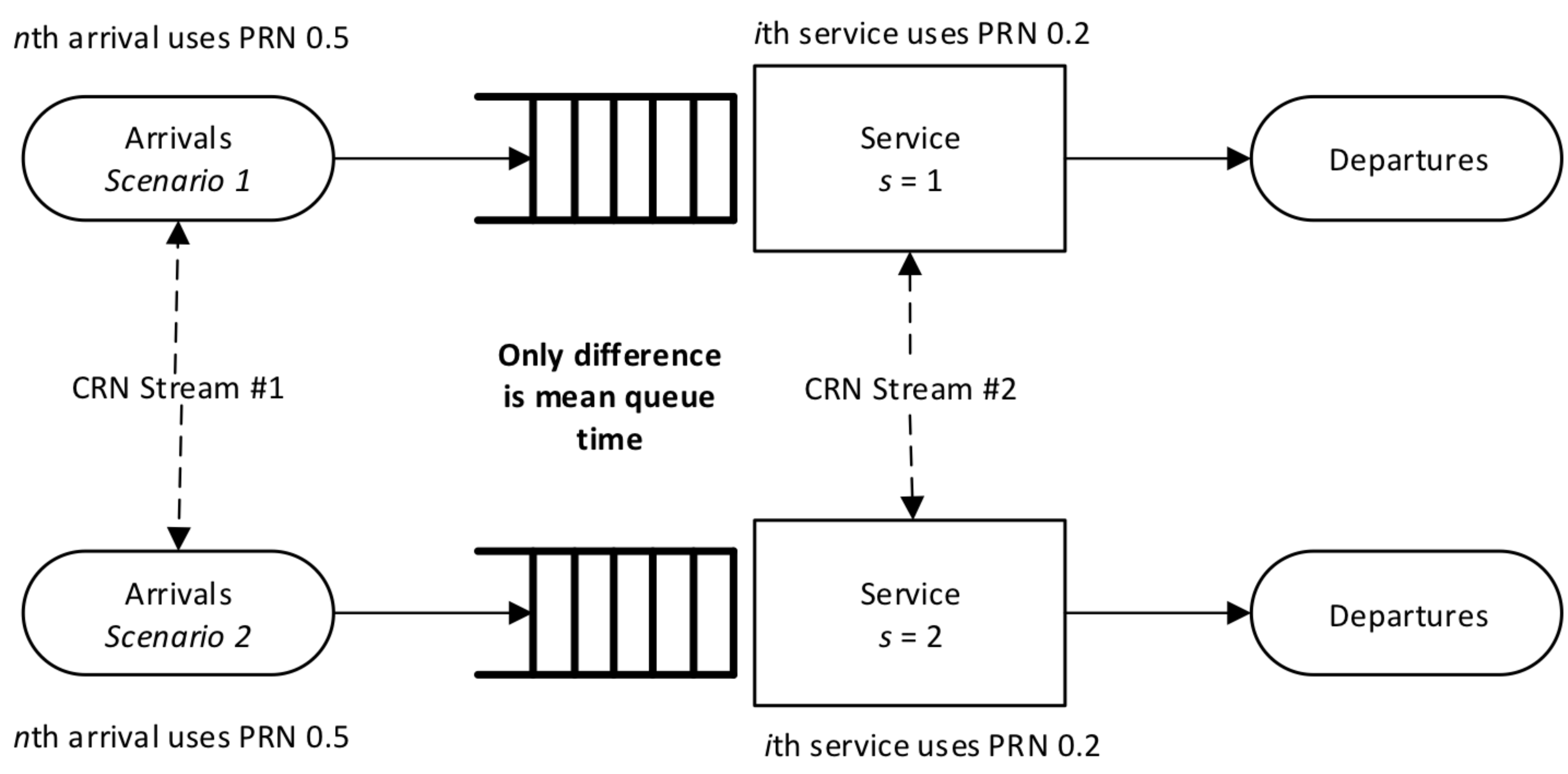
Arguments against the use of MCC

1. It often isn't practical

Scenarios	Comparisons (m)	α (Bonferroni)	CIs	
3	3	0.017	98.3	Interpretable, but wide CI's
4	6	0.008	99.2	
5	10	0.005	99.5	
6	15	0.003	99.7	Strict and CIs of little use
7	21	0.002	99.8	
8	28	0.002	99.8	
9	36	0.001	99.9	
10	45	0.001	99.9	

Bonferroni intervals = alpha / m e.g. 0.05/3 = 0.017 or a 98.3% CI.

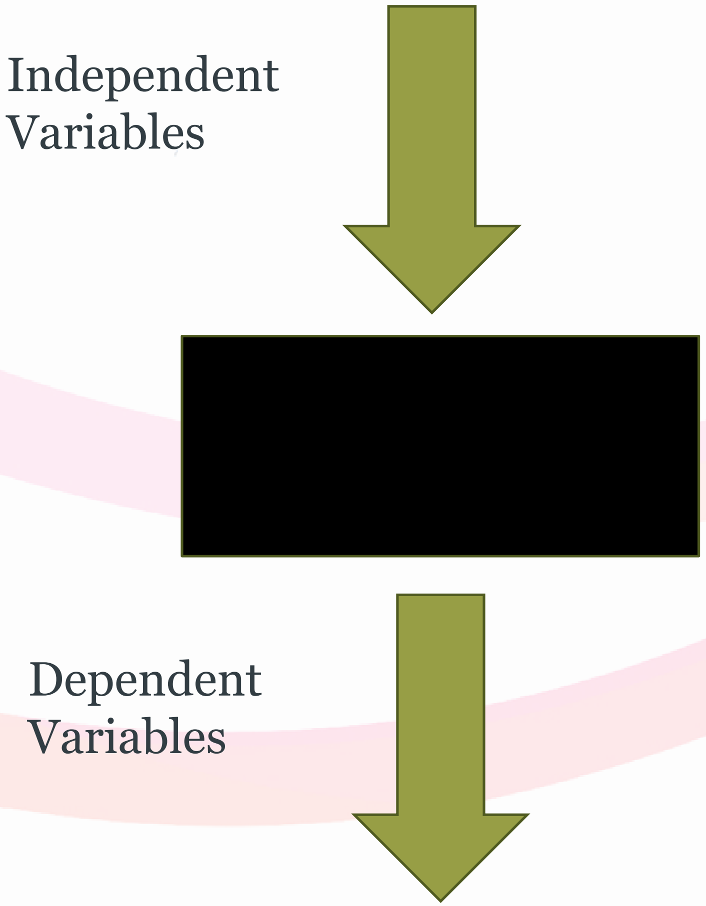
2. Common random numbers (CRN) "protect us"

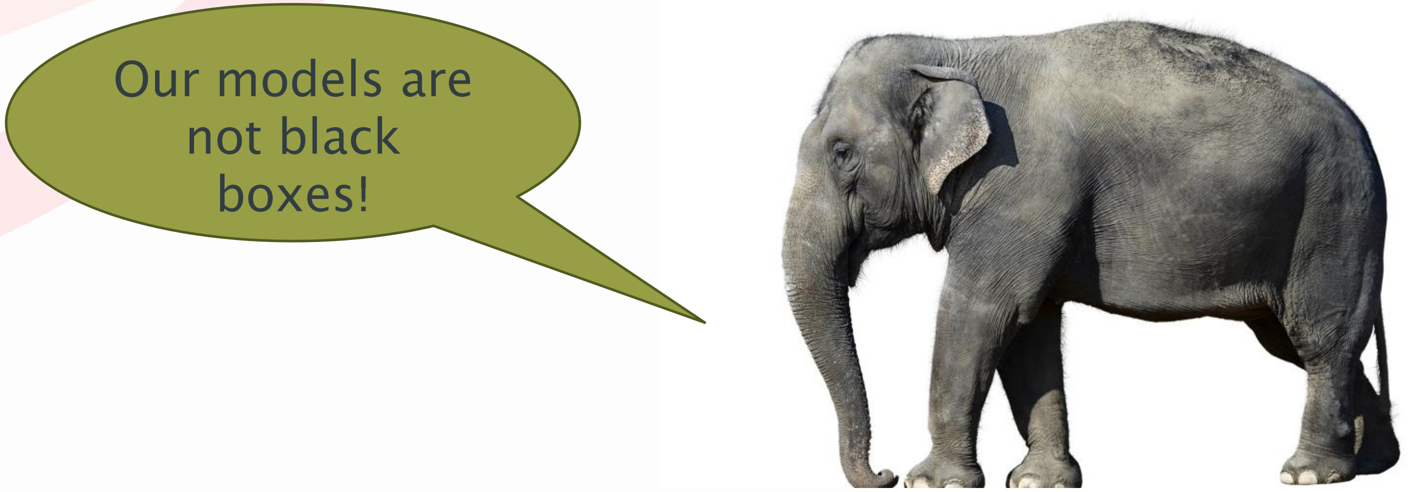


FWER cannot inflate at the rate predicted under these conditions.

3. Simulation is not a classical empirical study

- A big difference!
- We built the model.
- We can rerun the model.





Arguments for the use of MCC

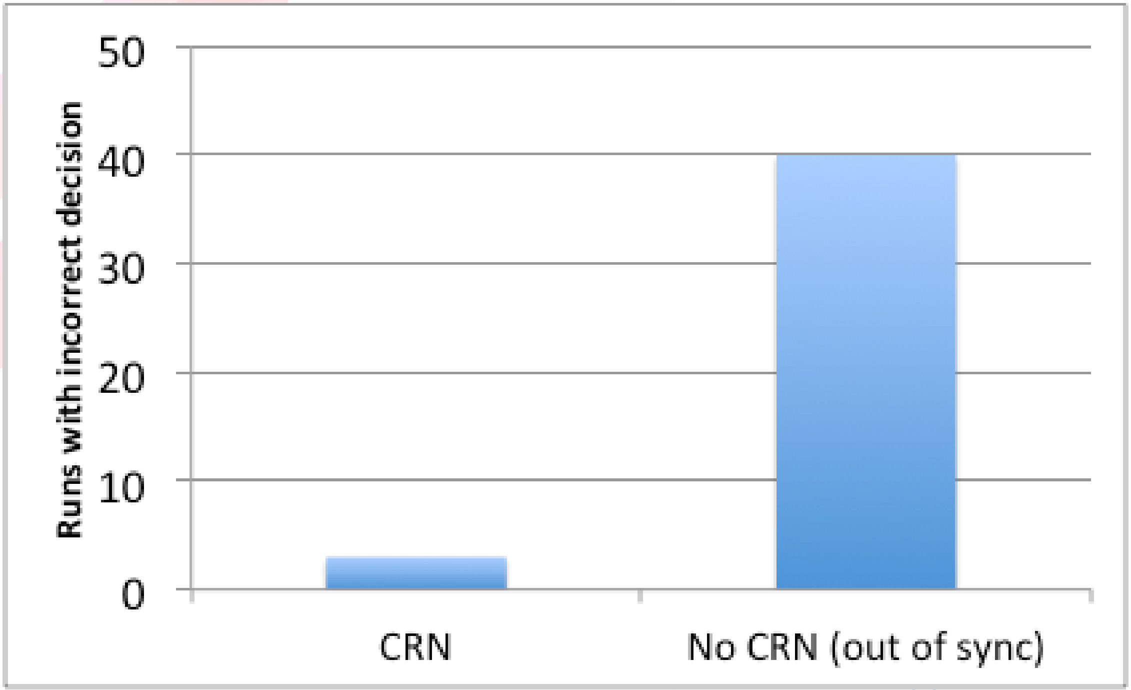
1. CRN do not always work!

- In complex models CRN might go out of sync. When this happens the MCP is a problem E.g.

- 100 replications of the following scenarios of an M/M/S system (adapted from Law (2006))
- Recorded the number of replications where the incorrect decision would be made.

Scenario	Parameters
M/M/1	$\rho = 0.9$ ($\lambda = 1$ min^{-1}; $\mu = 0.9$)
M/M/2	$\rho = 0.9$ ($\lambda = 1$ min^{-1}; $\mu = 1.8$)

- The correct decision is that the M/M/2 scenario has lower average queuing time.



2. An alternative to FWER control

- FWER control assumes that the role of the simulation study is to assist a decision maker is to pick the best system scenario out of n scenarios

- But complex models with many parameters are often used in an “exploratory” manner initially

- If the simulation study is more exploratory then control the **False Discovery Rate (FDR)**
  - Introduced by Benjamini and Hochberg (1995)
  - For algorithm and demo see Hoad and Monks (2011).

False Discovery Rates

Actual result	Decision		Total
	H_0 not rejected	H_0 rejected	
H_0 true	U	V	m_0
H_0 false	T	S	m_1
Total	m-r	R	m

V = the number of type I errors; T = the number of type II errors. Only m, r and m-r are observable. U, V, T, S and m_1 are unknown.

- Only m and R are known following a study
- FDR attempts to control E[V/R] (the expected number of Type I errors in all discoveries)
- As it is less “strict” you get less Type II errors (missing important results), but potentially some Type I errors (but less than if you have no MCC)

Final thoughts

- MCC is born out of the MCP in empirical studies.
- But does MCC really have a place in simulation studies as textbooks advocate?
- There are some compelling arguments that it is less of an issue, but mistakes can happen.
- For exploratory studies FDR procedures could be used over FWER control.
- If the goal of the study is to optimise then modellers should consider modern selection procedures (covered in paper) as opposed to MCC.

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Thanks for listening

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