	MATAPELAJARAN: Formal Methods			**MARKAH:**
	TOPIK:	**KOD: BCS2213**		
	PENILAIAN: QUIZ 4	**BIL: 1**	**MASA:** 90 Minutes	

SESI 2015/2016 SEMESTER 1

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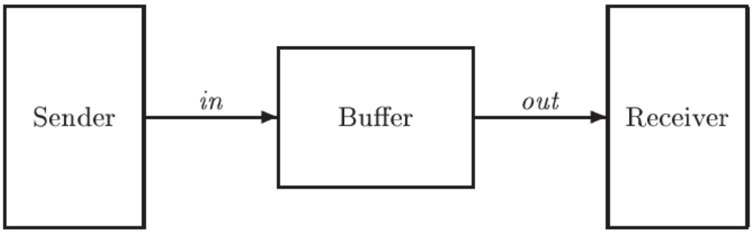
Quiz 4. TLA specification of the FIFO Protocol.

1. Modelling the FIFO (First In First Out) protocol.



- Sender and Receiver interact by messages passing (like in Async Interface);
- they communicate not directly, but via *Buffer*;
- Buffer has a FIFO inside, storing a *finite* number of messages.

2. Specification of FIFO.

- specification of FIFO **Extends** modules **Naturals** and **Sequences**.
- the **Sequences** module defines operations on finite sequences (tuples).
- TLA tuple is represented in ASCII with << >>
- the basic operations on the sequences are:

$Head(s)$ The first element of sequence s.
For example, $Head(\langle 3, 7 \rangle)$ equals 3.

$Tail(s)$ The tail of sequence s.
For example, $Tail(\langle 3, 7 \rangle)$ equals $\langle 7 \rangle$.

$Append(s, e)$ The sequence obtained by appending

element e to the tail of sequence s.
For example, $Append(\langle 3, 7 \rangle, 3)$ equals $\langle 3, 7, 3 \rangle$.

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3. Run TLA+ Toolbox and create new module with name Quiz_4_<your_ID>.tla

4. Define variable *Buf* as a tuple and apply to it all considered above operations on sequences.

Don't forget to define initial, next state predicates and combining it specification.

5. To understand the sense of the operations on sequences print the resulted *Buf* (for it, extend your module by TLC). Add inside the module commented output and your explanations.

6. Write TLA specification of FIFO protocol.

Send action appends a message to the *Buf*, ***Rcv*** action deletes a message from the *Buf*.

In order to TLC be able to generate state space, you also need define the constant ***Data***.

7. You have specified an unbounded FIFO, which can hold any number of messages.

However, any real system has a finite amount of resources, so FIFO can contain only a bounded number of messages. So action ***Send*** is enabled if there are fewer than *N* messages in the buffer, i.e. Len(*Buf*) is less than N, where N is some constant.

Add corresponding precondition to the action ***Send***.

8. Specification of the *upper* bound on FIFO was its *safety* property.

Specify *other safety* property for FIFO and check it. Give your explanations in comments.

9. Define a *liveness* property: a Buffer is *infinitely often* full or *infinitely often* empty.

10. Specify any other *livness* property for FIFO and check it with TLC. Give your explanations in comments.

11. Upload the Quiz into Kalam. It will be evaluated in max 2.5% of your total marks.