

No. of Continuation Sheets attached

Sheet No.



PUNJAB COLLEGES

Name: AHMAD TALHA ANSAR Roll No.: 2020-CS-420

Class: BS Computer Science Section (if any) A

Subject: Parallel and Distributed

Date:

Computer

Student's Signature:

Invigilator's Name: Signature:

(To be filled by the Examiner)

AWARD LIST

Q. No.	01 (MCQs)	02	03	04	05	06	07	08	09	10	Total Marks
Marks Obtained											

Examiner's Name: Signature:

Please start writing from here

Revolutionizing Big Data Analytics through
 Distributed computing and Clustering
 Techniques

Abstract:-

This project focuses on Big Data Analytics utilizing Distributed Computing and Clustering techniques. The project involves analyzing Non-Deterministic Finite Automata (NFA's), Labeled Transition Systems (LTS), Simple Traces of LTS, completed Traces of LTS and language equations to gain insights from the process of Big Data Analytics. Distributed computing is used to parallelize the processing of the data and speed up the analysis. Distributed clustering is used to group the data into clusters based on similarities/patterns. The results of the analysis will be used to make decisions or take actions based

on the insights gained from the data. The future impact of this project could be to improve the efficiency and accuracy of big data analytics in various domains. This could be include but not limited to software engineering, network security and business intelligence.

Keywords: Distributed computing, Clustering Techniques, Labeled Transition System and Business Intelligence.

Process of Big Data Analytics:-

- (1) Data Collection
- (2) Data Preprocessing
- (3) Data Storage
- (4) Data Partitioning
- (5) Cluster Setup
- (6) Data analysis
- (7) Data visualization
- (8) Decision Making

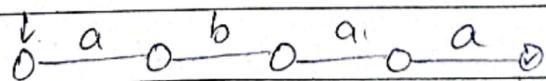
Labeled Transition System

① Data Collection

Data collection can be done from internal and external sources.

LTS-1

This LTS represents data collection from internal sources.



a: Data collection from sales.

ab: Data collection from HR

aba: Data collection from Finance

abaa: Data collected successfully

LTS-2

This LTS represents data collection from external sources.

↓
o-a-o-b-o-a-o-a-o

a: Data collected from Annual Reports

ab: Data collected from census deposits

aba: Data collected from press.

abaa: Data collection completed.

② Data Pre-processing.

Data pre-processing means cleaning data. Removing missing values, playing with outliers, and normalizing data.

LTS-3

This LTS represents the play with missing values and outliers.

↓
o-a-o-b-o-a-o-a-o

a: Analyzing Data

ab: Playing with missing values

aba: Playing with outliers

abaa: Copy of cleaned Data.

LTS-4

This LTS represents standardization and normalization process on the dataset, got from LTS-3.

↓
o-a-o-b-o-a-o-a-o

: Doing standardization

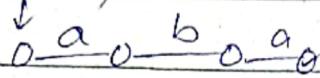
ab: Doing normalization

ba: Filtering rows/columns

abaa: Copy of cleaned Data.

③ Data Storage

The preprocessed data is stored in distributed storage system, such as Hadoop Distributed File System (HDFS). **LTS-5**



a: Get Preprocessed data

ab: Store Pre-processed data

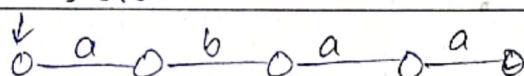
aba: Data storage completed

④ Data Partitioning

The stored data is partitioned into smaller subsets and distributed across clusters of computers to enable parallel processing.

LTS-6

This LTS represents partitioning of data into smaller subsets.



a: Access stored data

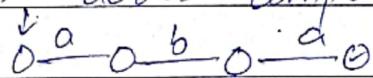
ab: Select no. of parti

aba: Make data partitions

abaa: Store partitions in Database

LTS-7

This LTS represents the distribution of data's partitions across computers.



a: Select No. of computers

ab: Assign positions to com

aba: Store those partitions into computer.

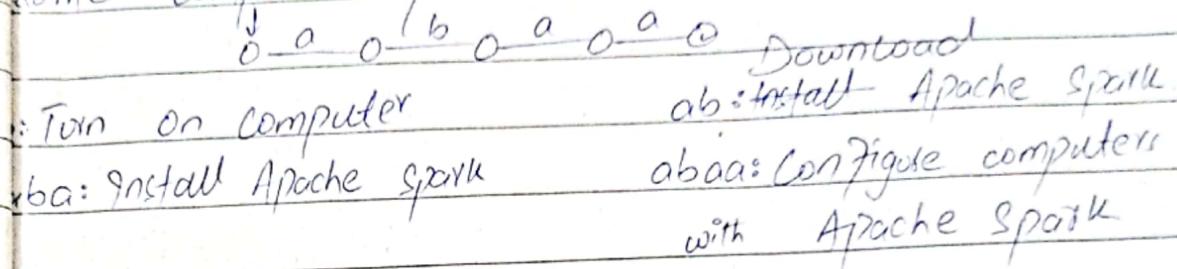
(2)

⑤ Cluster Setup

The cluster of computers is configured with software like Apache Spark/Hadoop, to enable distributed computing.

LTS-8

This LTS represents the configuration of some computers from cluster with Apache Spark.



LTS-9

This LTS represents configuration of computers with Hadoop.

LTS-9

↑ Turn On computer.

ba: Install Hadoop

ab: Download Hadoop

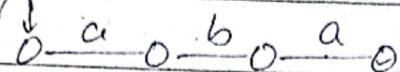
aba: Configure it and process completed.

⑥ Data Analysis

The data is analysed using distributed computing techniques such as MapReduce/Spark. This allows for parallel processing on multiple partitions of data, simultaneously.

LTS-10

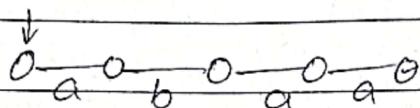
This LTS represents choosing eight correlation method for data.



- a: Listing all correlation methods
aba: Choosing eight method.
- ab: Running each correlation method.

LTS-11

This LTS represents the running of MapReducer on data.



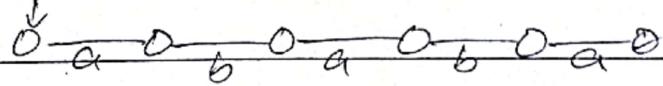
- a: Selecting partitions
aba: Binding best results
- ab: Running MapReducer.
abaa: Storing best results.

⑦ Data Visualization

The insights gained from data analysis are visualized using tools such as Tableau, which make it easier to interpret the results.

LTS-12

This LTS represents the making and visualization of bar charts



- a: Put data in tableau
aba: Select No. of bins
ababa: Interpret results.
- ab: Select bar-chart
abab: Visualize bar-chart

LTS-13

This LTS represents the making and visualization of pie chart.



: Load data in Tableau

ab: Select Pie Chart

b2: Make Pie Chart(Proces) abaa: Interpret results.

LTS-14

This LTS represents making and visualization of waterfall chart for numerical data.



: Load data into Tableau

ab: Select numerical data.

ba: Select waterfall chart

abab: waterfall chart process.

bab: Interpret results.

⑨ Decision Making

The final step is to read the results to make decisions. Visualization charts and data analysis will help in this process.

LTS-15

This LTS represents making decision from diff. visualizations.



: Understanding all visualizations

b: Thinking about many decisions.

ba: Taking the right decision.

bac: Implementing the right decision.

Traces of all LTSIs

- 1 Trace = { e, a, ab, aba, abaa, abaaav }
- 2 Trace = { e, a, ab, aba, abaa, abaaav }
- 3 Trace = { e, a, ab, aba, abaa, abaaav }
- 4 Trace = { e, a, ab, aba, abaa, abaaav }
- 5 Trace = { e, a, ab, aba, abav }
- 6 Trace = { ae, a, ab, aba, abaa, abaaav }
- 7 Trace = { e, a, ab, aba, abav }
- 8 Trace = { e, a, ab, aba, abaa, abaaav }
- 9 Trace = { e, a, ab, aba, abaa, abaaav }
- 10 Trace = { e, ab, ab, aba, abaa, abaaav }
- 11 Trace = { e, a, ab, aba, abab, ababav }
- 12 Trace = { e, a, ab, aba, abaa, abaaav }
- 13 Trace = { e, a, ab, aba, abaa, abaaav }
- 14 Trace = { e, a, ab, aba, abab, ababav }
- 15 Trace = { e, a, ab, aba, abaa, abaaav }

Simple Process Equivalence

LTS	Equivalent LTSIs
1	2, 3, 4, 6, 8, 9, 11, 13, 15
2	1, 3, 4, 6, 8, 9, 11, 13, 15
3	1, 2, 4, 6, 8, 9, 11, 13, 15
4	1, 2, 3, 6, 8, 9, 11, 13, 15
5	7, 10
6	1, 2, 3, 4, 8, 9, 11, 13, 15
7	5, 10
8	1, 2, 3, 4, 6, 9, 11, 13, 15
9	1, 2, 3, 4, 6, 8, 11, 13, 15

(3)

10	5, 10, 7
11	1, 2, 3, 4, 6, 8, 9, 13, 15
12	14
13	1, 2, 3, 4, 6, 8, 9, 11, 15
14	12.
15	1, 2, 3, 4, 6, 8, 9, 11, 13.

Completed Trace Equivalence

LTS Completed Trace Equivalent LTS's

1	2, 3, 4, 6, 8, 9, 11, 13, 15
2	1, 3, 4, 6, 8, 9, 11, 13, 15
3	1, 2, 4, 6, 8, 9, 11, 13, 15
4	1, 2, 3, 6, 8, 9, 11, 13, 15
5	7, 10
6	1, 2, 3, 4, 6, 8, 9, 11, 13, 15
7	5, 10
8	1, 2, 3, 4, 6, 9, 11, 13, 15
9	1, 2, 3, 4, 6, 8, 11, 13, 15
10	7, 5
11	1, 2, 3, 4, 6, 8, 9, 13, 15
12	14
13	1, 2, 3, 4, 6, 8, 9, 11, 15
14	12
15	1, 2, 3, 4, 6, 8, 9, 11, 13.

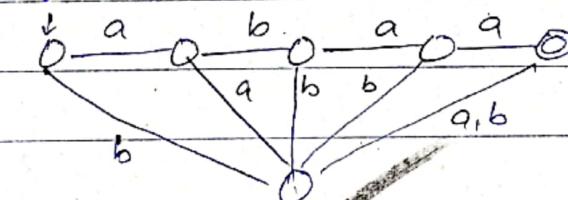
NOTE:

- $[1, 2, 3, 4, 6, 8, 9, 11, 13, 15]^{\text{LTS}^{\text{IS}}}$ are not completed trace equivalent to $[5, 7, 10, 12, 14]$ LTS's since their simple traces are not equivalent and vice versa.
- $[12, 14]$ LTS's are not equivalent (completed trace) to $[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15]$ since their simple traces aren't equivalent and vice versa.
- $[5, 7, 10]$ LTS's (traces) aren't eg completed traces equivalent to $[1, 2, 3, 4, 6, 8, 9, 11, 12, 13, 14, 11]$ since their simple traces aren't equivalent and vice versa

Deterministic Labelled Transition System

An LTS is called deterministic if for every state s and action a , there is atmost one state t such that $s \xrightarrow{a} t$.

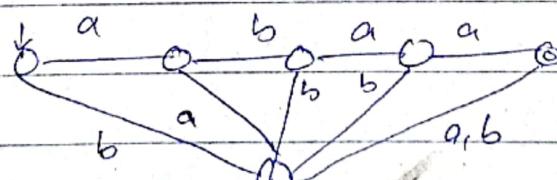
DLTS-1



{ abaa }



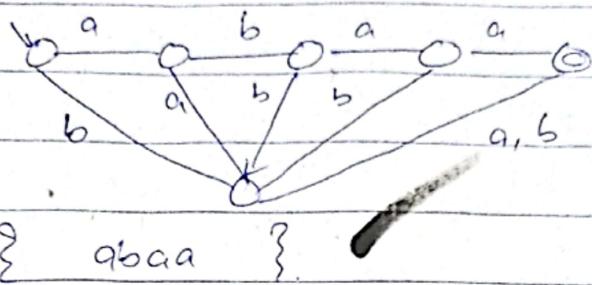
DLTS-2



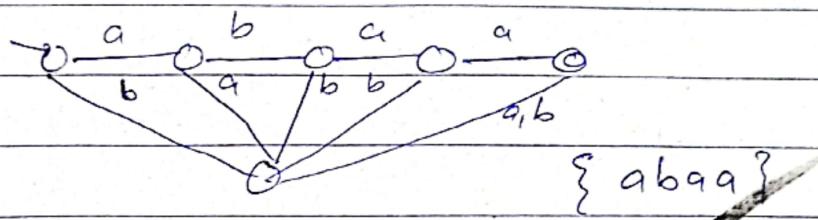
{ aabb aa }



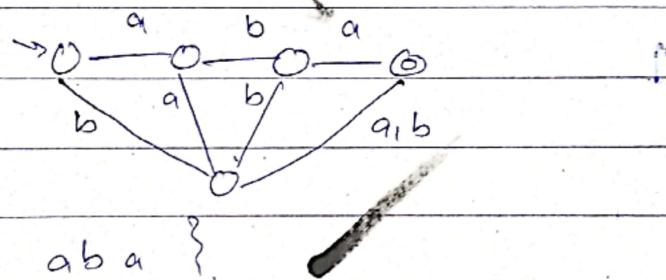
DLTS-3



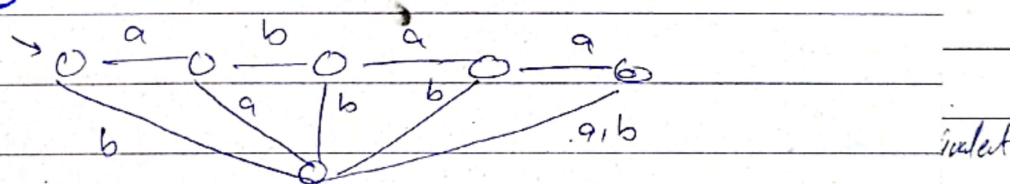
DLTS-4



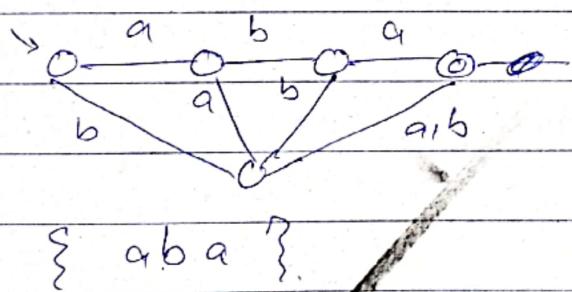
DLTS-5



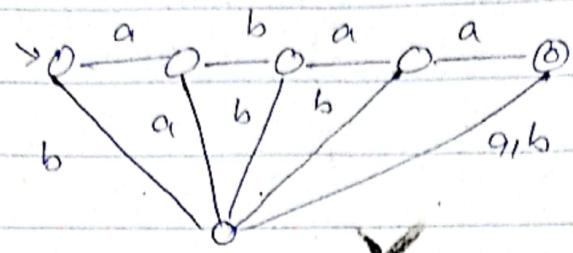
DLTS-6



DLTS-7

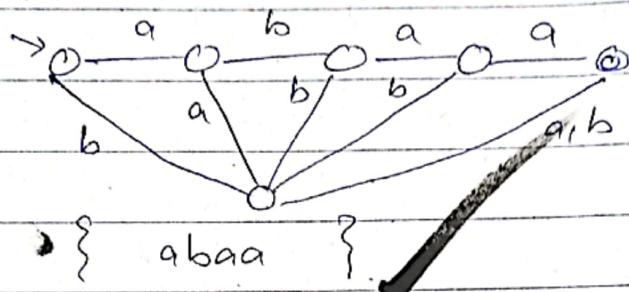


DLTS-8



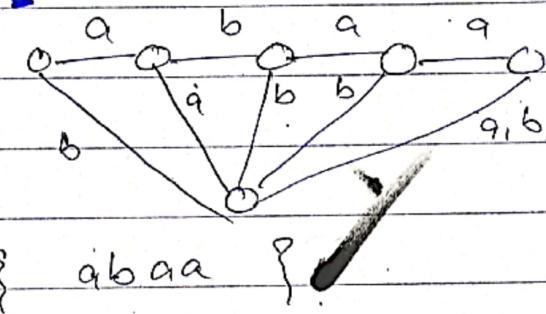
{ abaa }

DLTS-9



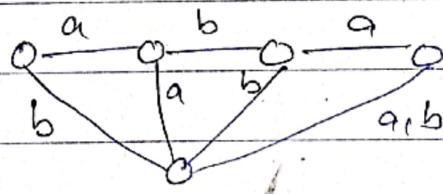
{ abaa }

DLTS-10



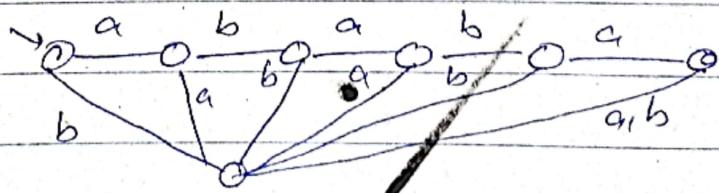
{ abaa }

DLTS-10



{ abaa }

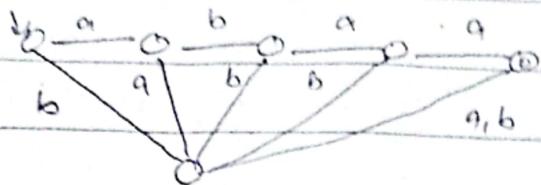
DLTS-12



{ ababaa }

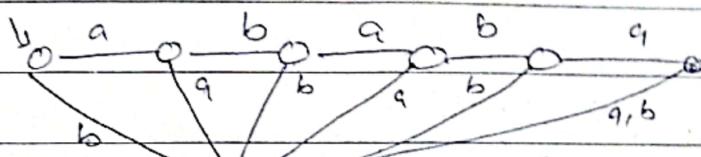
(u)

DLTS-13



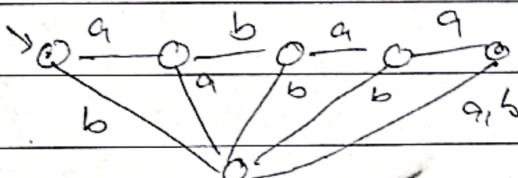
{ abaa }

DLTS-14



{ .ababa }

DLTS-15



{ abaa }

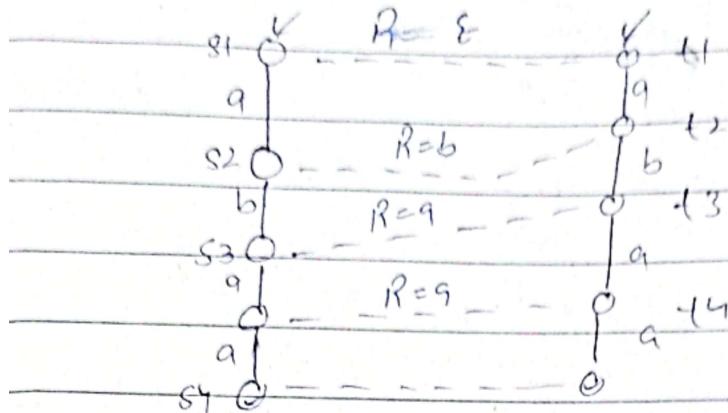
Language Equivalence

to each other.

- DLTS [1, 2, 3, 4, 6, 8, 9, 11, 13, 15] are language equivalent
- DLTS [12, 14] are language equivalent to each other.
- DLTS [5, 10, 7] are language equivalent to each other.

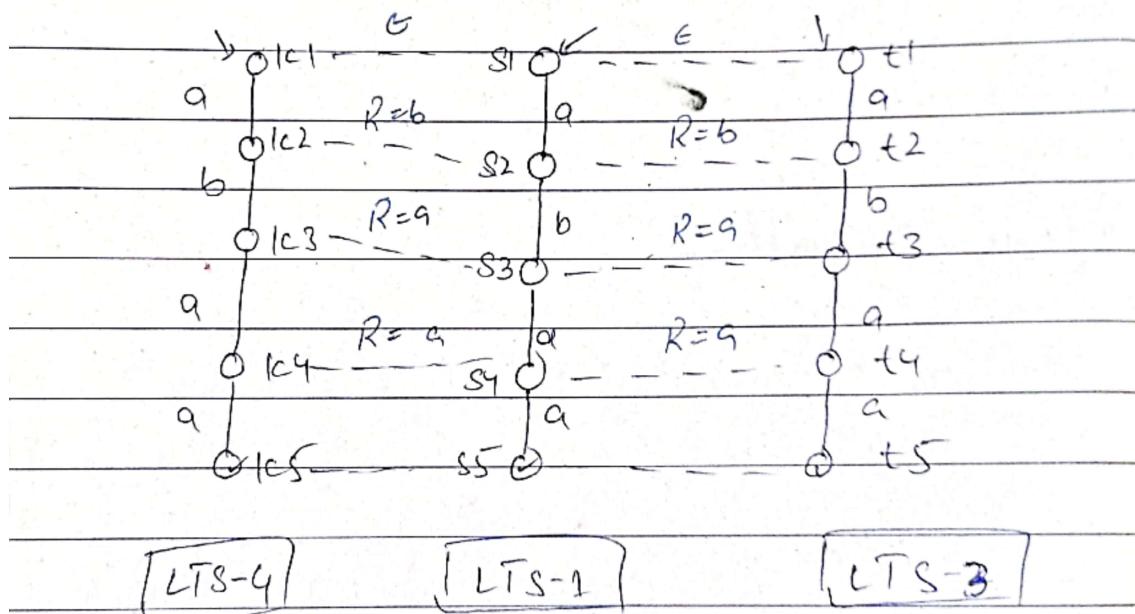
Strong Bisimulation

Finding Strong Bisimulation of LTS 1 - All.
LTS-1 - LTS-2



LTS-1 and LTS-2 are strongly bisimulated.

LTS-1 - LTS-3 - LTS-4



[LTS-4]

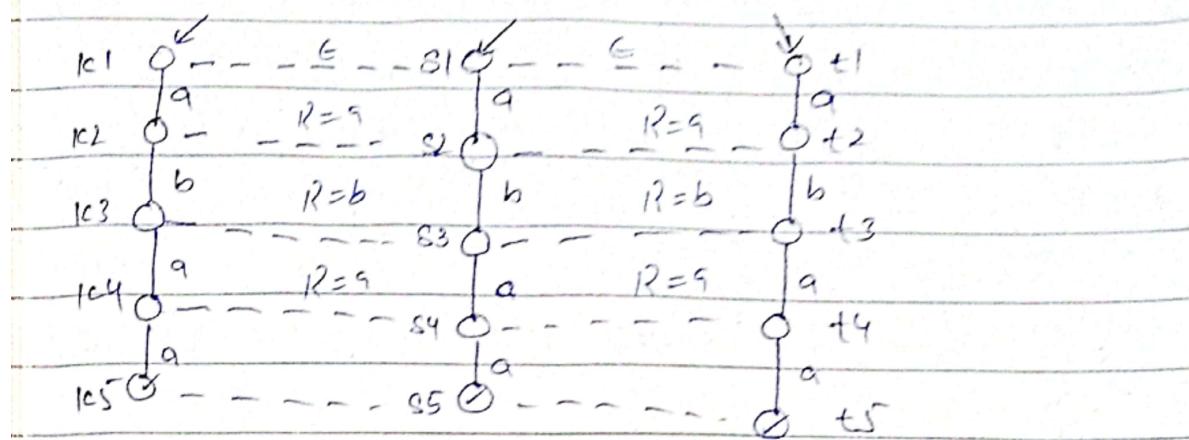
[LTS-1]

[LTS-3]

LTS-1 is strongly bisimulated to LTS
3 and LTS-4

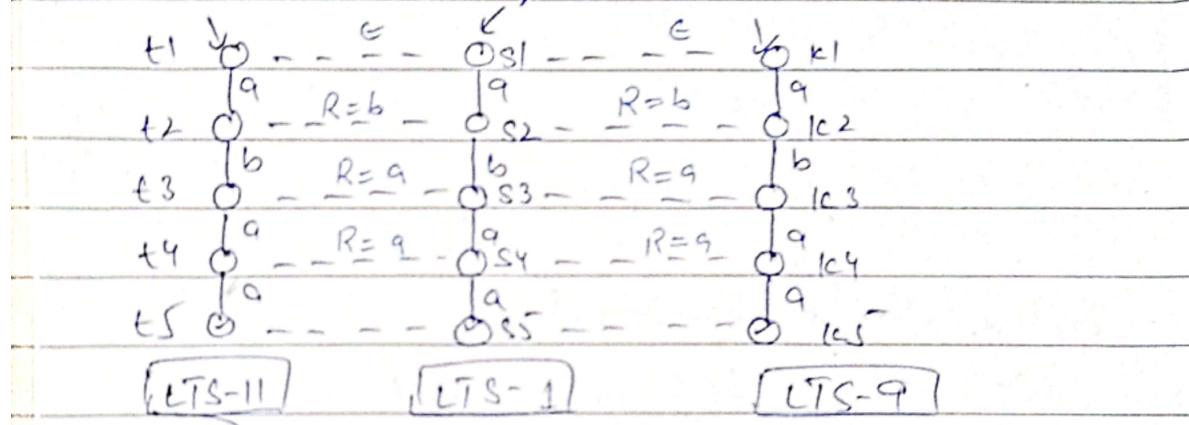
(5)

$LTS-1 \rightarrow (LTS-6, 8)$



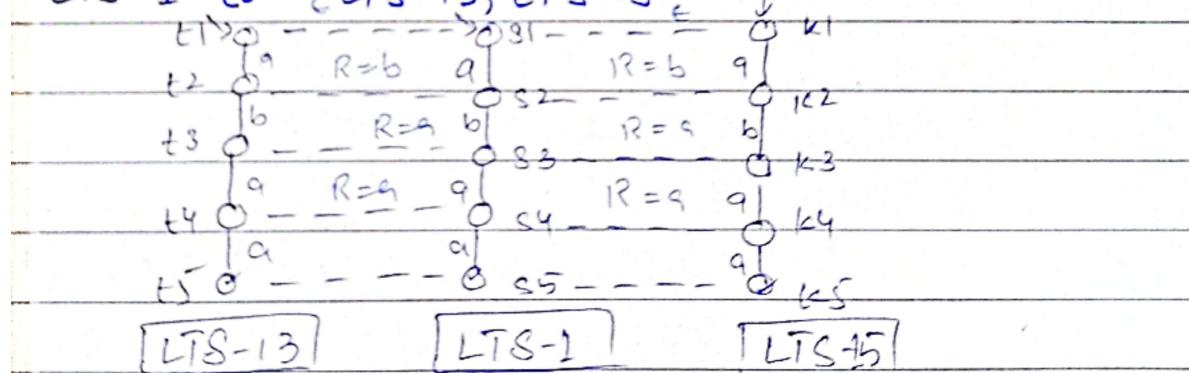
$LTS-1$ is strongly bisimulated with $LTS-6$ and $LTS-8$.

$LTS-1 \rightarrow LTS-9, LTS-11$



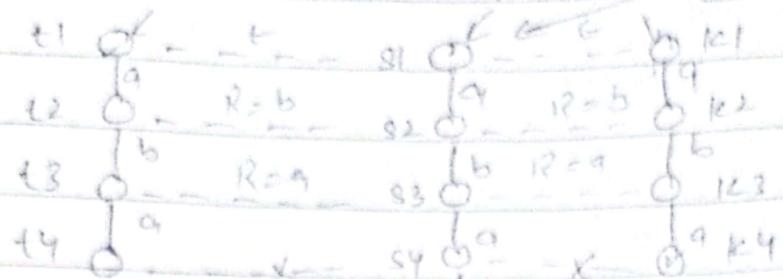
$LTS-1$ is strongly bisimulated with $LTS-9, LTS-11$.

$LTS-1 \rightarrow LTS-13, LTS-15$



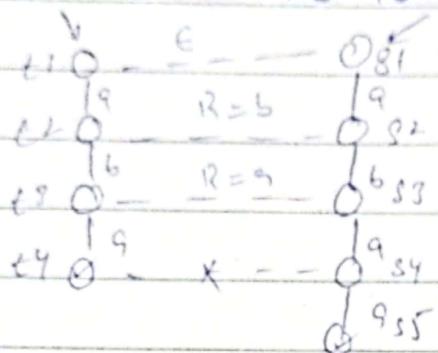
$LTS-1$ is strongly bisimulated with $LTS-13$ and $LTS-15$.

LTS-1 to LTS-5, 7. [LTS-1]



LTS-1 is strongly bisimulated to LTS-5 and LTS-7.

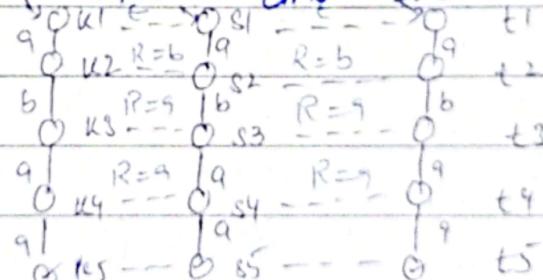
LTS-1 to LTS-10



LTS-1 is strongly bisimulated to LTS-10.

Finding strong bi-simulation of LTS-2

LTS-2 to LTS-3 and LTS-4

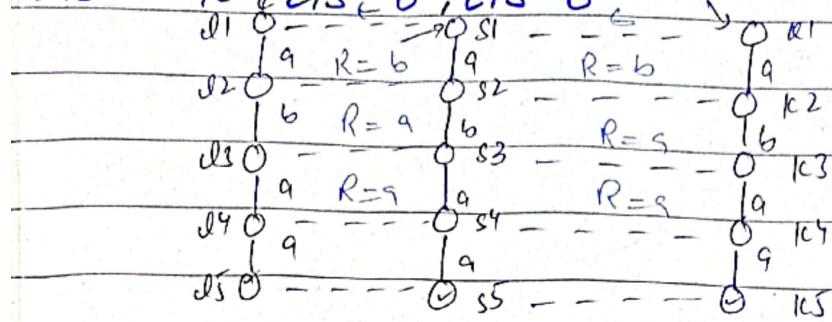


[LTS-4] [LTS-2] [LTS-3]

LTS-2 is strongly bi-simulated to LTS-3 and LTS-4.

(6)

LTS-2 to LTS-6, LTS-8



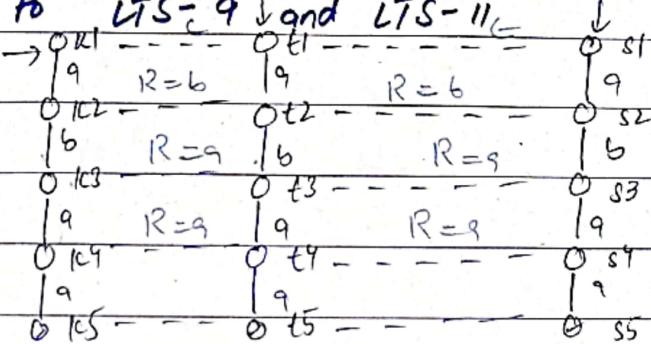
[LTS-8]

[LTS-2]

[LTS-6]

LTS-2 is strongly bi-simulated to LTS-6 and LTS-8

LTS-2 to LTS-9 and LTS-11



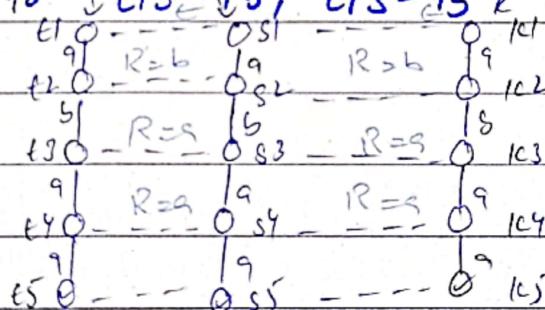
[LTS-11]

[LTS-2]

[LTS-9]

LTS-2 is strongly bi-simulated to LTS-9 and LTS-11.

LTS-2 to LTS-13, LTS-15



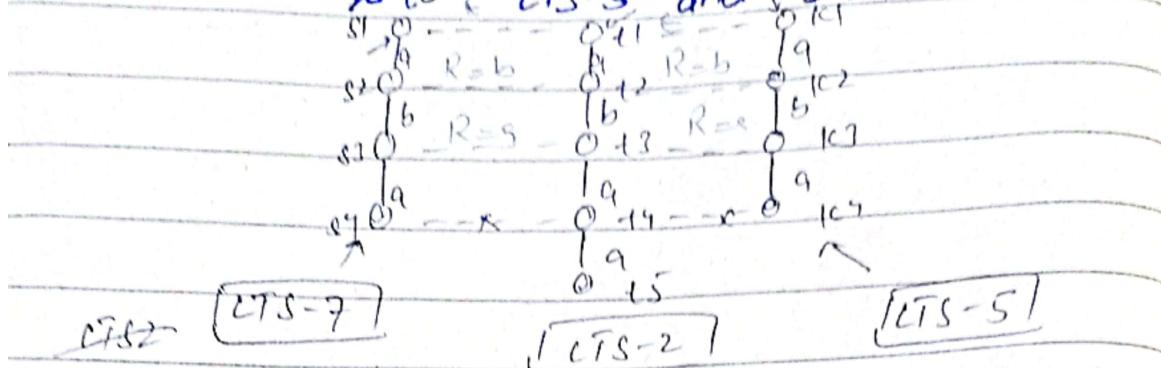
[LTS-13]

[LTS-2]

[LTS-15]

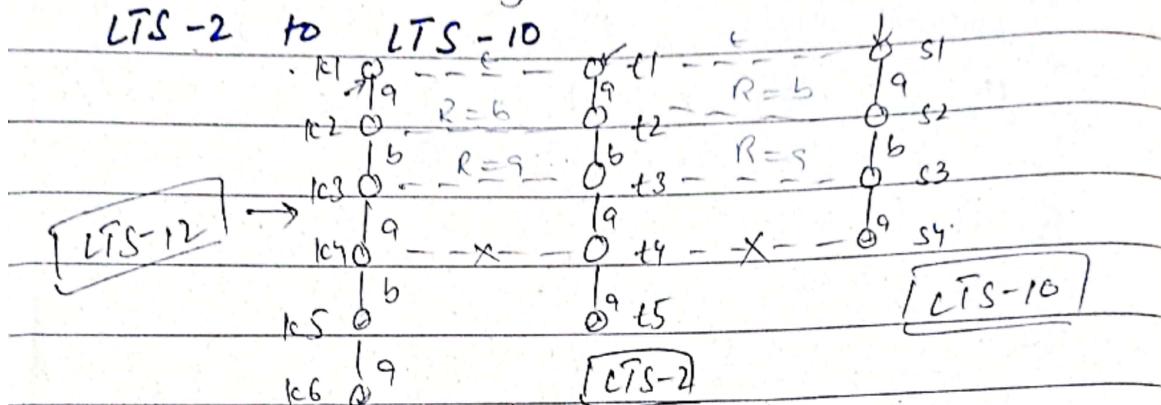
LTS-2 is strongly bi-simulated to LTS-13 and LTS-15.

LTS-2 is to LTS-5 and LTS-7.



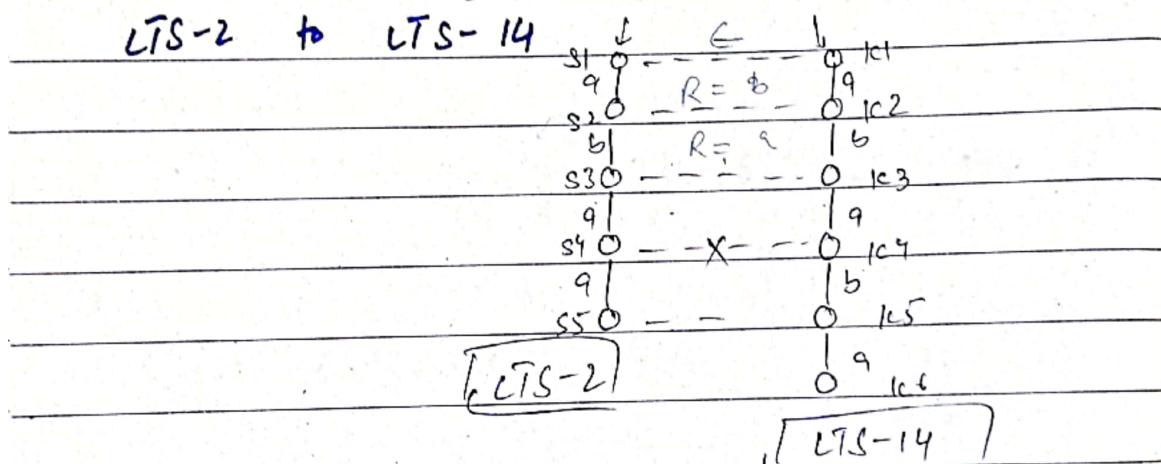
LTS-2 is not strongly bisimulated to LTS-5 and LTS-7.

LTS-2 to LTS-10



LTS-2 isn't strongly bi-simulated to LTS-10 and LTS-12.

LTS-2 to LTS-14



LTS-2 isn't strongly bi-simulated to LTS-14.

7

Finding bi-simulation for LTS-3

LTS-3 to LTS-4, and LTS-5 ↓

$$\begin{aligned}
 & \text{S1} \quad \theta^1 - \frac{\partial}{\partial x} - \theta^1_{x1} L = \theta^1_{x1} \\
 & \text{S2} \quad \theta^2 - \frac{\partial}{\partial y} - \theta^2_{y2} L = \theta^2_{y2} \\
 & \text{S3} \quad \theta^3 - \frac{\partial}{\partial z} - \theta^3_{z3} L = \theta^3_{z3} \\
 & \text{S4} \quad \theta^4 - \frac{\partial}{\partial t} - \theta^4_{t4} L = \theta^4_{t4} \\
 & \text{S5} \quad \theta^5 - \frac{\partial}{\partial \bar{x}} - \theta^5_{\bar{x}5} L = \theta^5_{\bar{x}5}
 \end{aligned}$$

LTS-4 LTS-3 LTS-6

LTS-3 is strongly bi-simulated with LTS-4 and LTS-6.

LTS-3 to LTS-8 and LTS-9

$$\begin{array}{ccccccc}
 01 & 0 & - & - & 0 & 0 & 0 \\
 02 & 0 & - & R=b & 0 & R=b & 0 \\
 03 & 0 & - & R=a & 0 & R=a & 0 \\
 04 & 0 & - & - & 0 & R=a & 0 \\
 05 & 0 & - & - & 0 & R=5 & 0
 \end{array}$$

LTS-8 LTS-3 LTS-9

LTS-3 is strongly bi-simulated with LTS-8 and LTS-9.

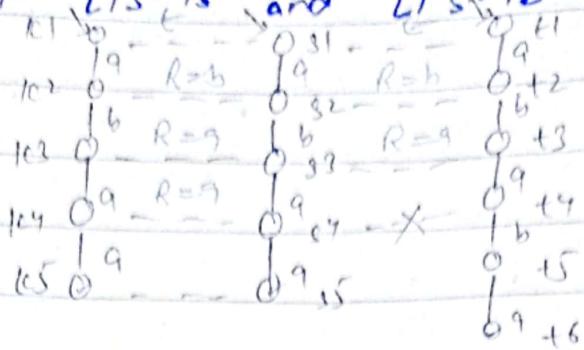
LTS-3 to LTS-11 and LTS-13

t1	O^9	$\text{R}=50$	O^9	$\text{R}=6$	O^9	SI
t2	O^9	$\text{R}=50$	O^9	$\text{R}=6$	O^9	S2
+3	O^9	$\text{R}=9$	O^9	$\text{R}=9$	O^9	S3
+4	O^9	$\text{R}=9$	O^9	$\text{R}=9$	O^9	S4
+5	O^9	$\text{R}=105$	O^9	$\text{R}=87$	O^7	S5

LTS-11 LTS-3 LTS-13

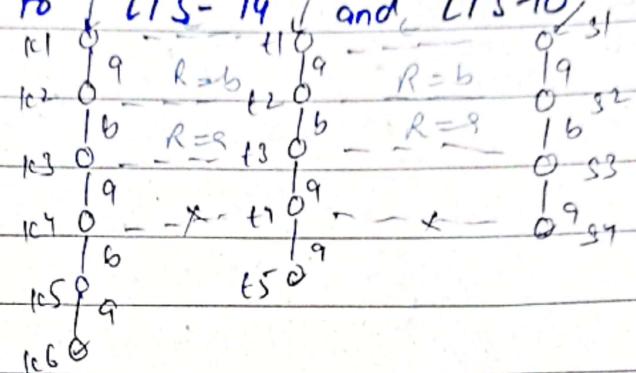
LTS-3 is strongly bi-simulated to LTS-11 and LTS-13.

LTS-3 to LTS-15 and LTS-12



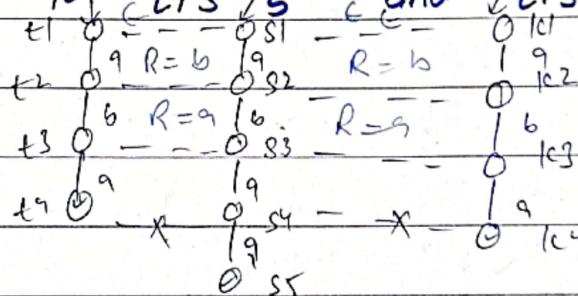
LTS-3 is strong bi-simulated to LTS-15 and not bi-simulated to LTS-12.

LTS-3 to LTS-14 and LTS-10



LTS-3 isn't strong bisimulated to LTS-14 and LTS

LTS-3 to LTS-5 and LTS-7

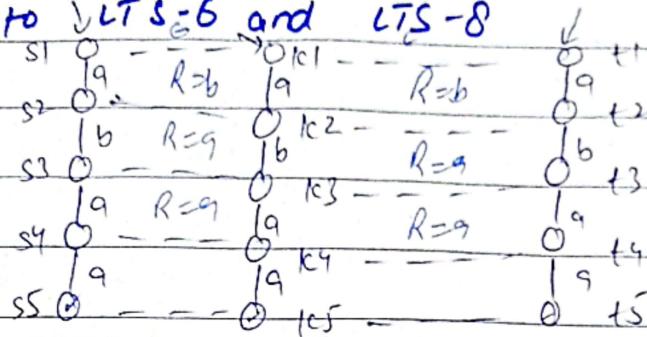


LTS-3 is not strong bi-simulated to LTS-5 and LTS-7

(8)

Finding LTS-4 (strong Bi-simulation).

LTS-4 to \cup LTS-6 and LTS-8



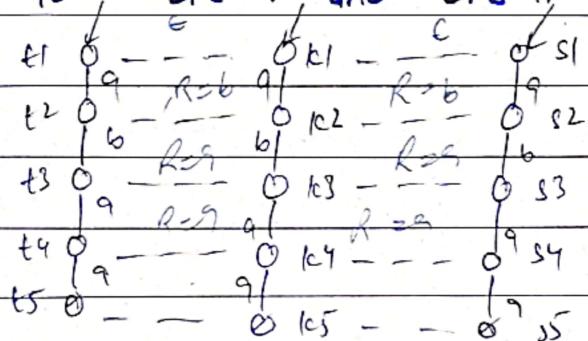
LTS-6

LTS-4

LTS-8

LTS-4 is strongly bi-simulated to LTS-6 and LTS-8.

LTS-4 to LTS-9 and LTS-11



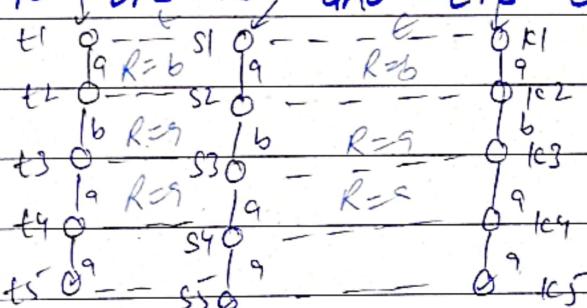
LTS-9

LTS-4

LTS-11

LTS-4 is strongly bi-simulated to LTS-9 and LTS-11.

LTS-4 to \cup LTS-13 and LTS-15



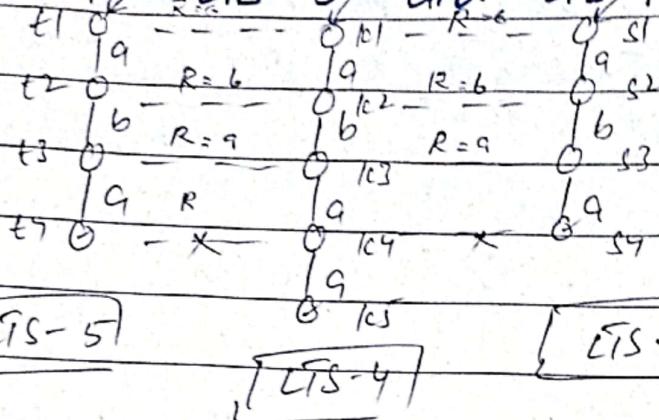
LTS-15

LTS-4

LTS-13

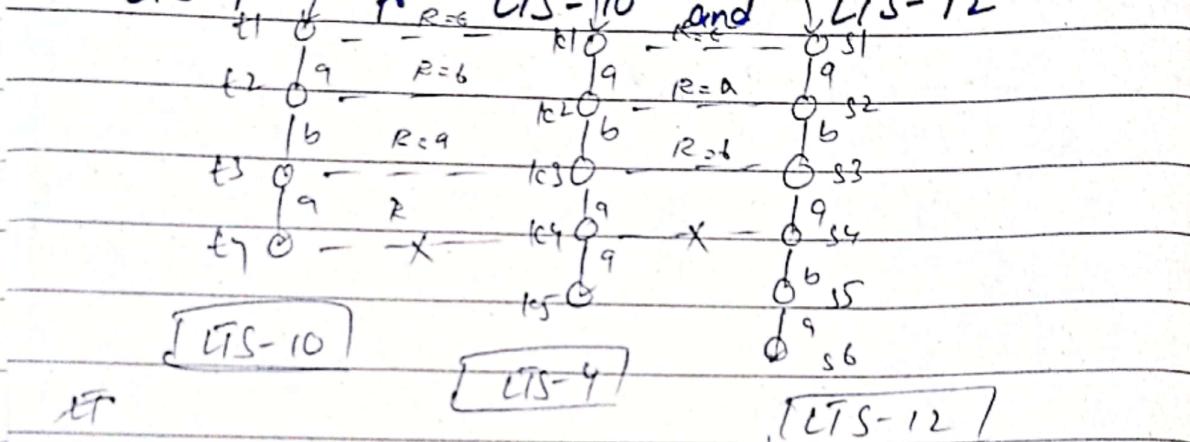
LTS-4 is strongly bi-simulated to LTS-15 and LTS-13.

LTS-4 to LTS-5 and LTS-7



LTS-4 isn't strong bi-simulated to LTS-5 and LTS-7

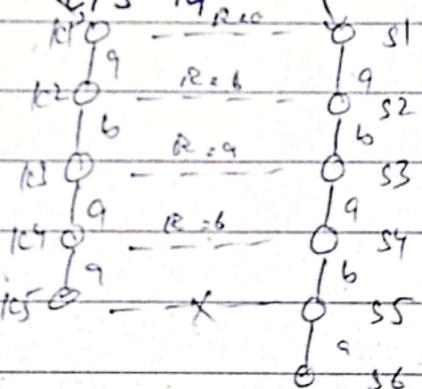
LTS-4 to LTS-10 and LTS-12



LTS-4 isn't strong bi-simulated to LTS-10 and LTS-12

LTS-4 to

LTS-14

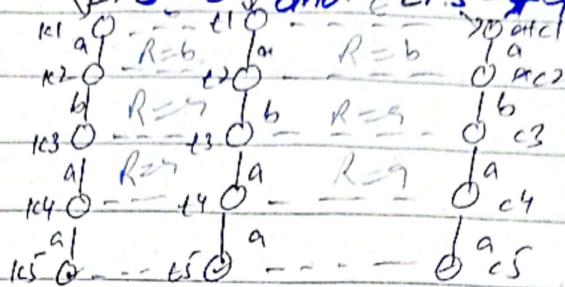


LTS-4 isn't strong bi-simulated to LTS-14.

(9)

Finding strong Bi-Simulation for LTS-6

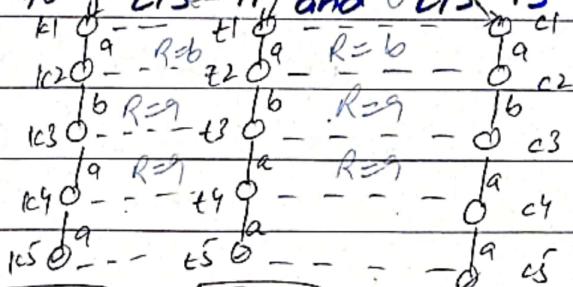
LTS-6 to LTS-8 and LTS-9



$\boxed{LTS-9}$ $\boxed{LTS-6}$ $\boxed{LTS-8}$

LTS-6 is strongly bi-simulated to LTS-8 and LTS-9.

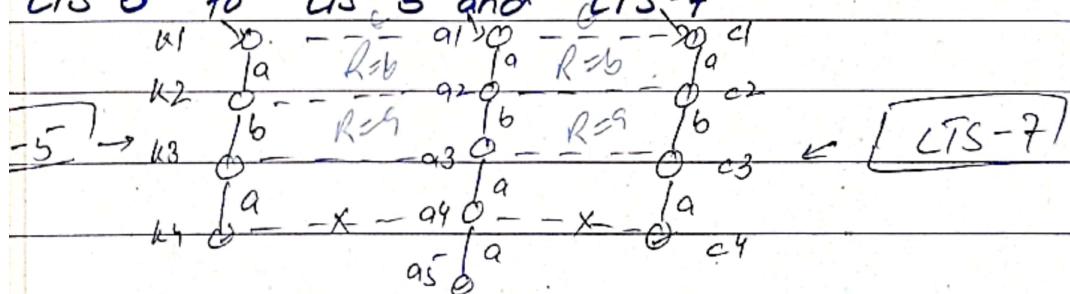
LTS-6 to LTS-11 and LTS-13



$\boxed{LTS-13}$ $\boxed{LTS-6}$ $\boxed{LTS-11}$

LTS-6 is strongly bi-simulated to LTS-11 and LTS-13.

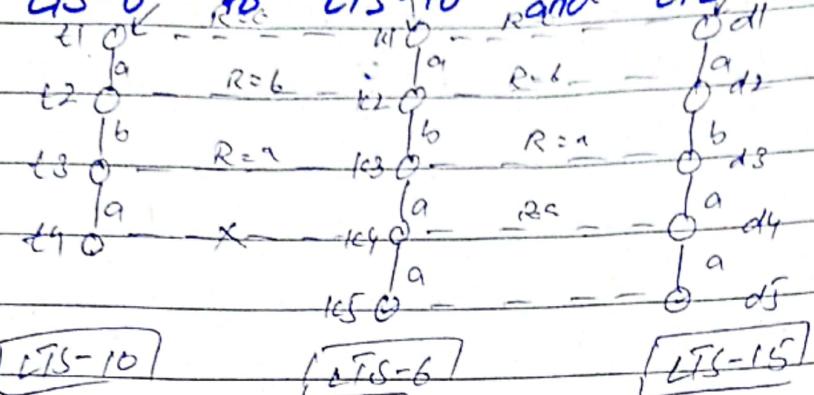
LTS-6 to LTS-5 and LTS-7



$\boxed{LTS-7}$

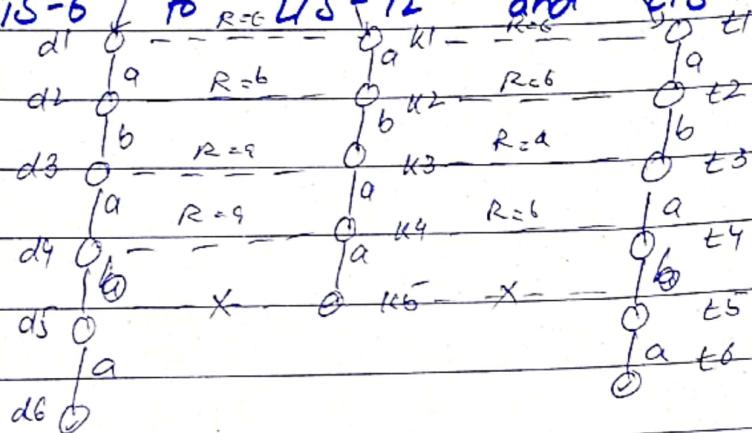
LTS-6 isn't strongly bi-simulated to LTS-5 and LTS-7

LTS-6 to LTS-10 and LTS-15



LTS-6 is strong bi-simulated to LTS-15 and not strong bi-simulated to LTS-10

LTS-6 to LTS-12 and LTS-14

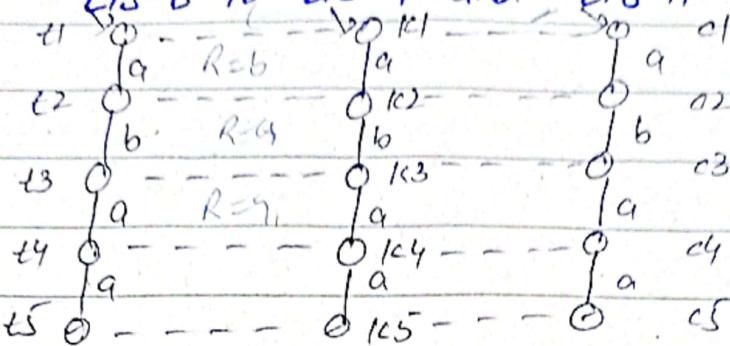


LTS-6 isn't strongly bisimulated to LTS-12 and LTS-14.

(10)

Finding Strong bisimulation for LTS-8

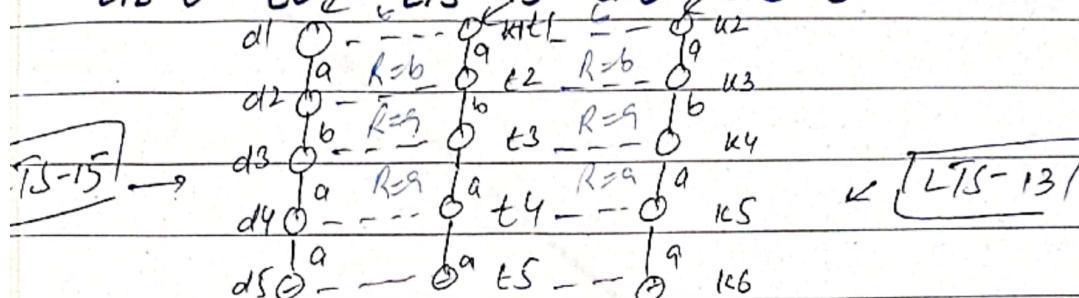
LTS-8 to LTS-9 and LTS-11



[LTS-11] [LTS-8] [LTS-9]

LTS-8 is strongly bi-simulated to LTS-9 & LTS-11

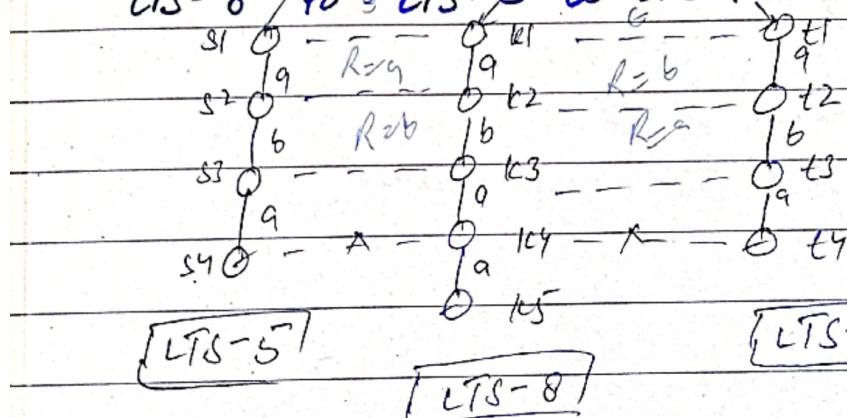
LTS-8 to LTS-13 and LTS-15



[LTS-8]

LTS-8 is strongly bi-simulated to LTS-13 & LTS-15.

LTS-8 to LTS-5 & LTS-7



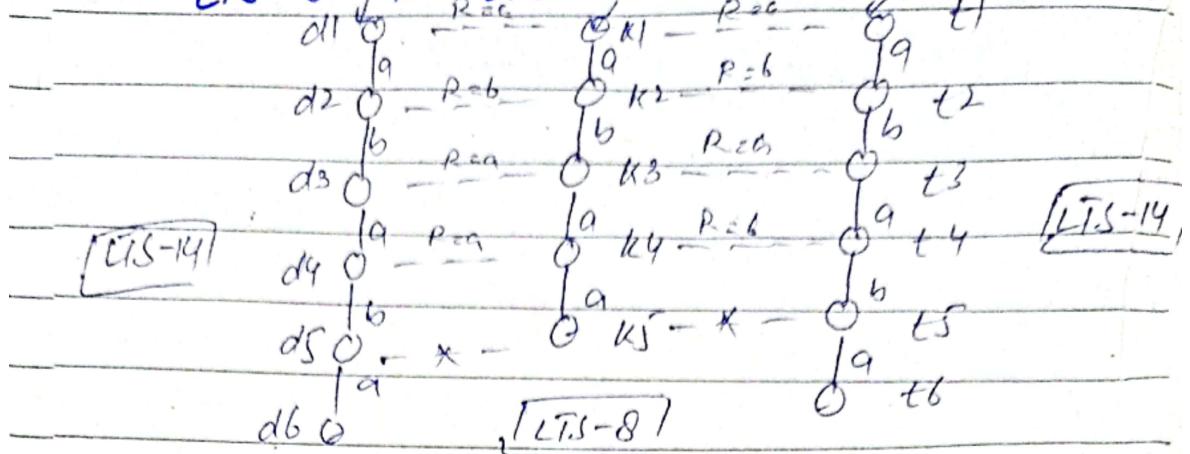
[LTS-5]

[LTS-8]

[LTS-7]

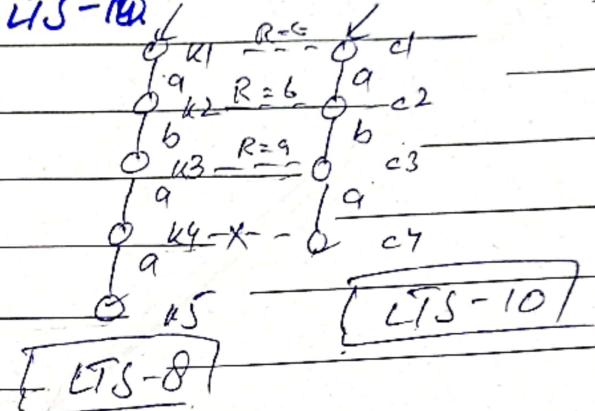
LTS-8 isn't strong bi-simulated with
LTS-5 and LTS-7.

LTS-8 to LTS-12 and LTS-14



LTS-8 isn't strongly bi-simulated to LTS-12
and LTS-14.

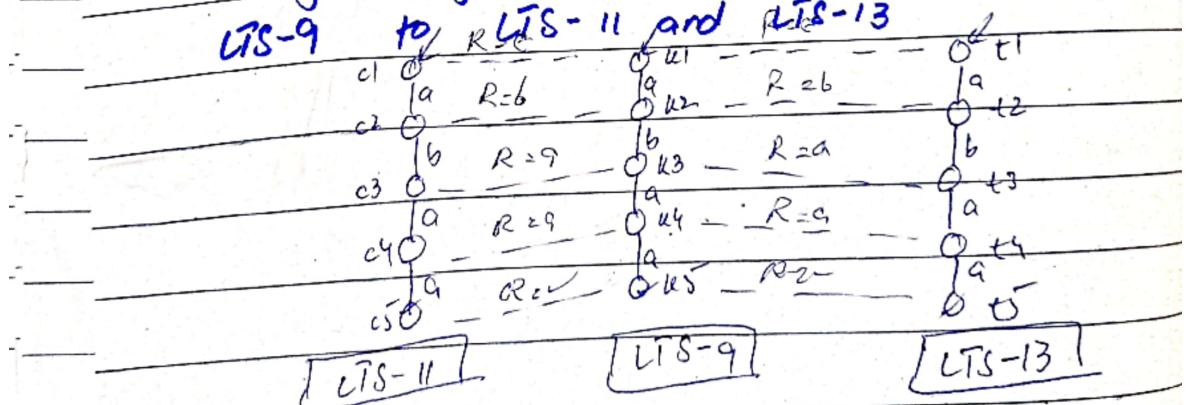
LTS-8 to LTS-10



LTS-8 isn't strongly bi-simulated to LTS-10.

Finding Strong Bi-simulation of LTS-9

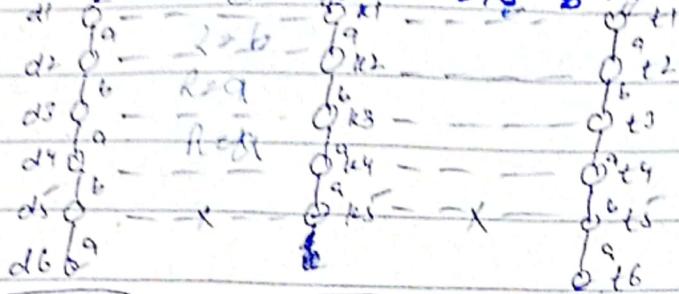
LTS-9 to LTS-11 and LTS-13



LTS-9 is strongly equivalent to LTS-11 and LTS-13

(11)

LTS-9 to LTS-712 and LTS-814



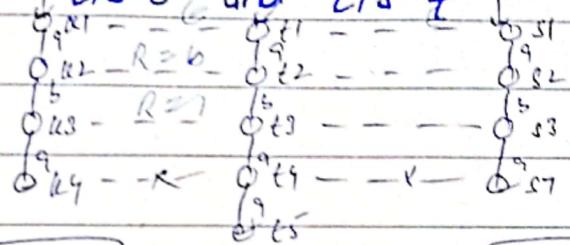
[LTS-14]

[LTS-9]

[LTS-12]

LTS-9 isn't equivalent to LTS-12 and LTS-14.

LTS-9 to LTS-5 and LTS-7



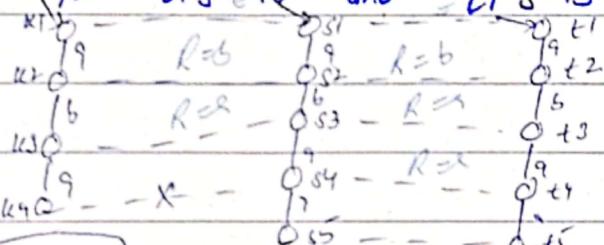
[LTS-5]

[LTS-9]

[LTS-7]

LTS-9 isn't equivalent to LTS-5 and LTS-7.

LTS-9 to LTS-10 and LTS-15



[LTS-10]

[LTS-9]

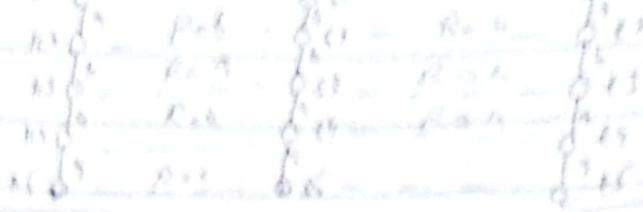
[LTS-15]

LTS-

LTS-9 isn't equivalent to LTS-10 and LTS-15.

Finding Strong Bisimulation for LTS-10

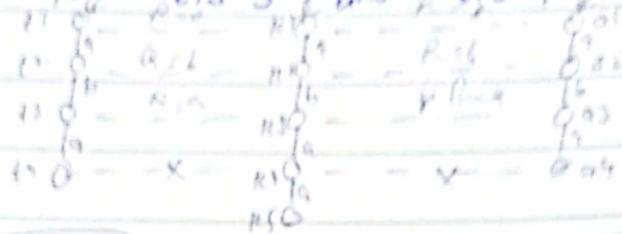
LTS-10 to LTS-11 and LTS-13



LTS-11 LTS-10 LTS-13

LTS-10 isn't equivalent to LTS-11 and LTS-13

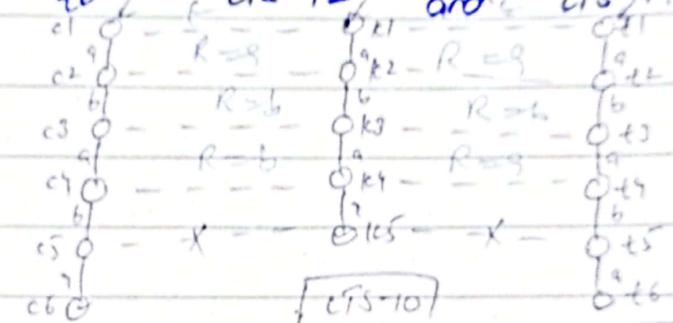
LTS-10 to LTS-5 and LTS-7



LTS-5 LTS-10 LTS-7

LTS-10 isn't equivalent to LTS-5 and LTS-7

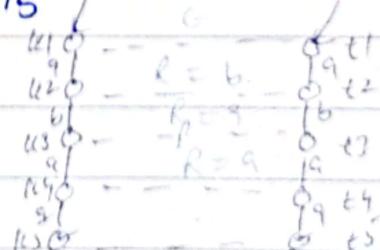
LTS-10 to LTS-12 and LTS-14



LTS-10 LTS-10 LTS-12

LTS-10 isn't equivalent to LTS-12 and LTS-14.

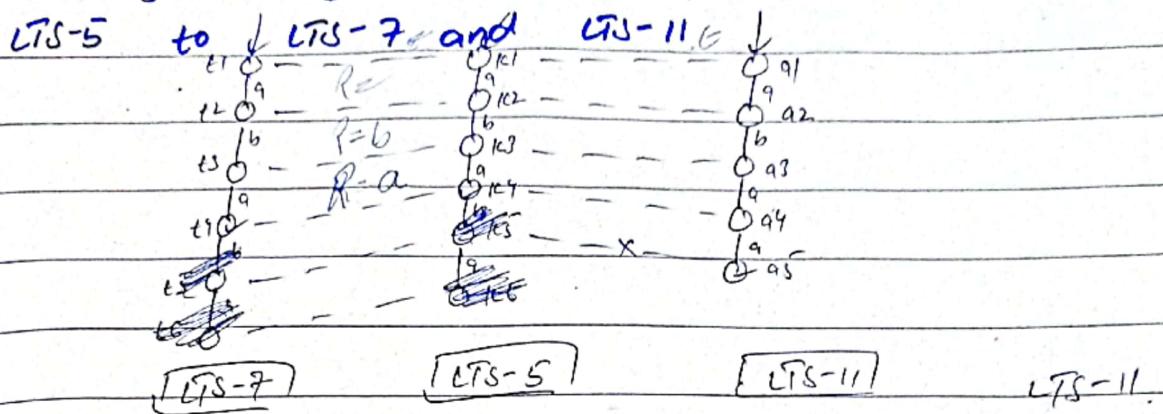
LTS-10 to LTS-15



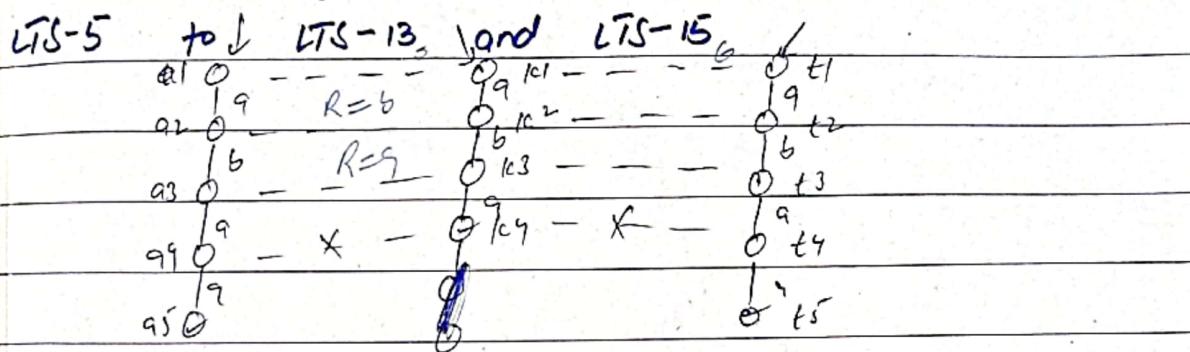
LTS-10 is equivalent to LTS-15.

(12)

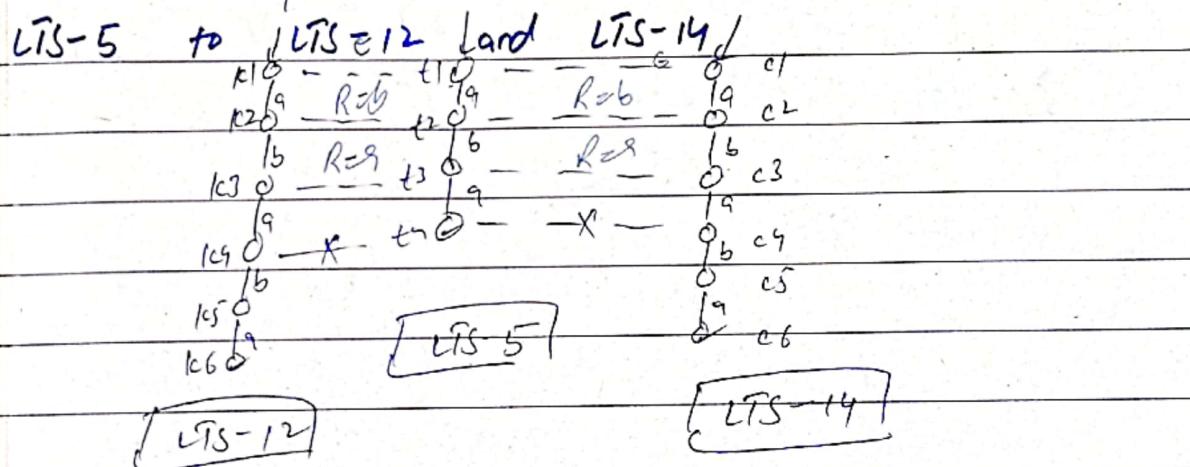
Finding strong Bi-simulation for LTS-5



LTS-5 is strong bi-simulated to LTS-7 and not to LTS-11.



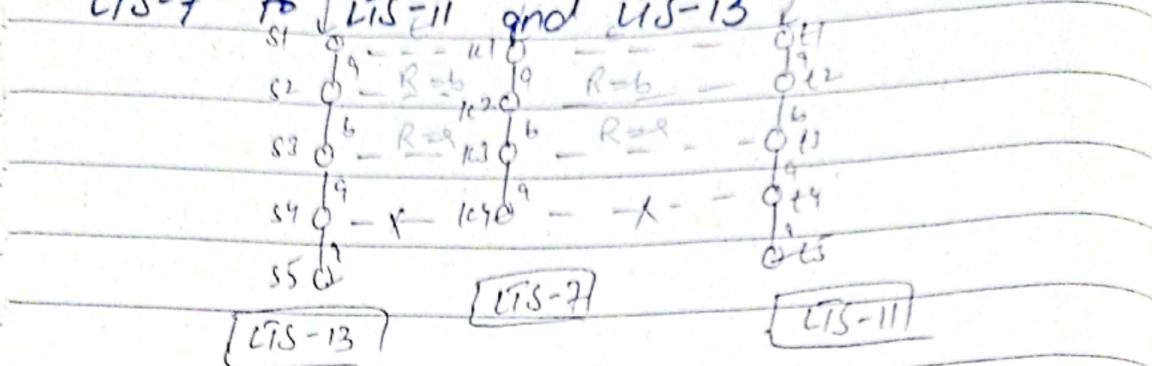
LTS-5 isn't equivalent to LTS-13 and LTS-15.



LTS-5 isn't strong bi-simulated to LTS-12 and LTS-14.

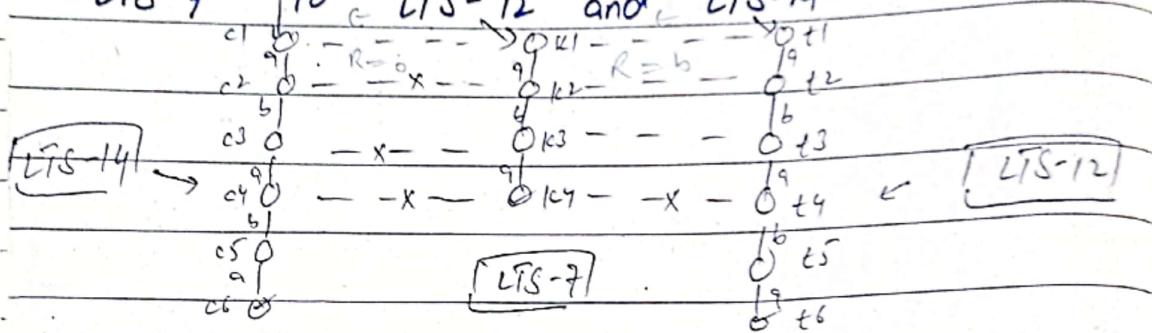
Finding Strong Bi-equivalent to LTS-7

LTS-7 to LTS-11 and LTS-13



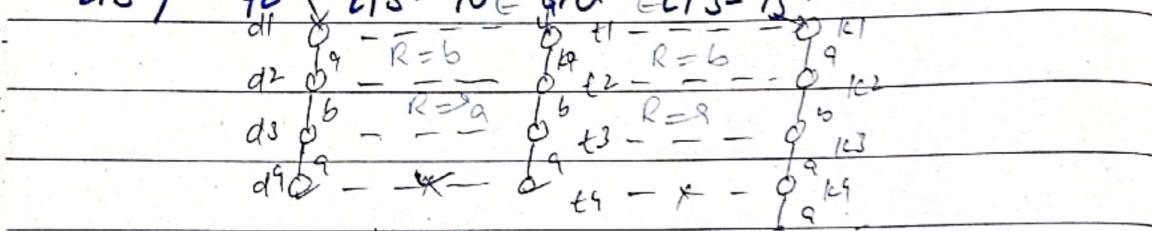
LTS-7 is not equivalent to LTS-11 and LTS-13.

LTS-7 to LTS-12 and LTS-14



LTS-7 is not equivalent to LTS-12 and LTS-14.

LTS-7 to LTS-10 and LTS-15

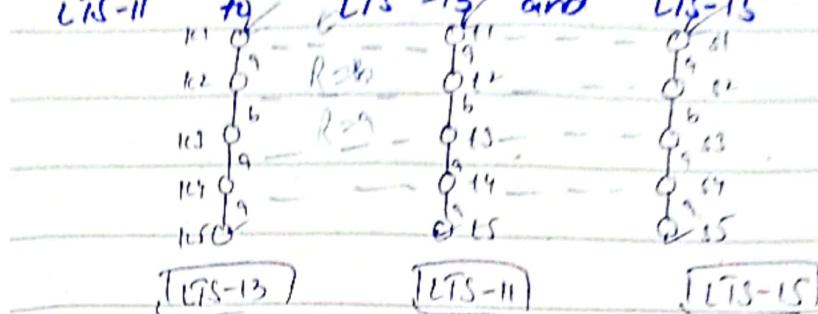


LTS-7 is equivalent to LTS-10 and not equivalent to LTS-15.

(13)

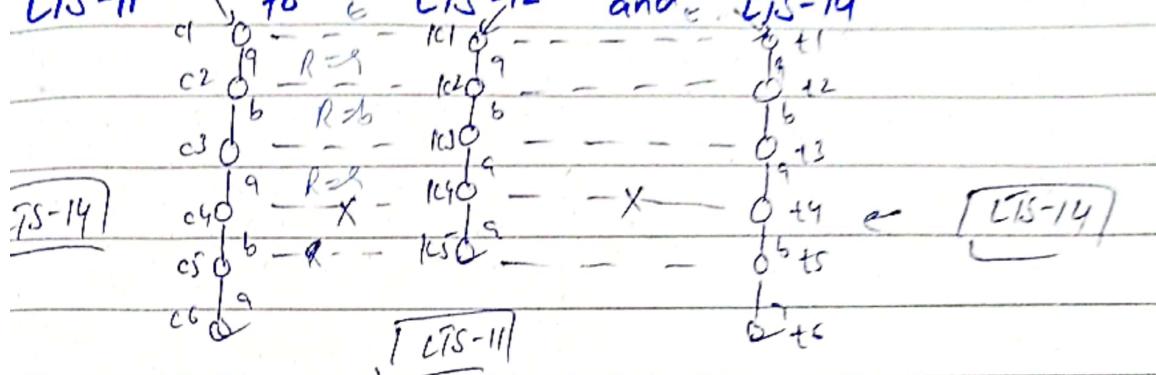
Binding Strong Bi-Simulation for LTS-11

LTS-11 to LTS-13 and LTS-15



S-11 is strong bi-simulated to LTS-13 and LTS-15.

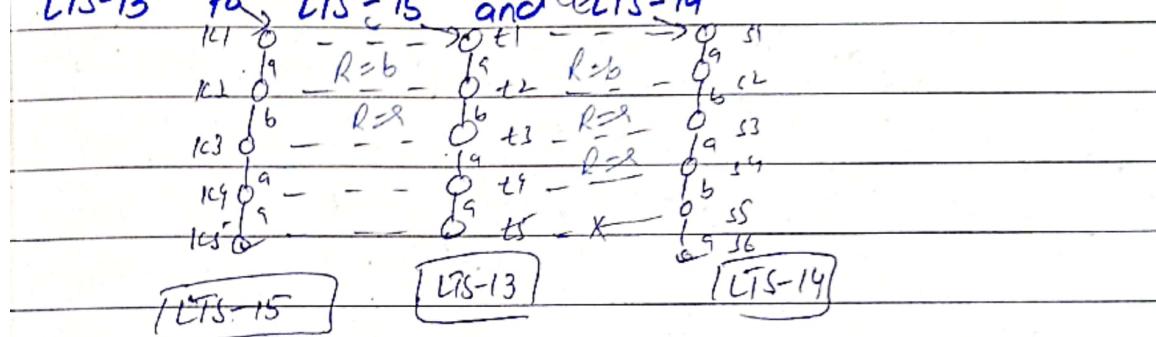
LTS-11 to LTS-12 and LTS-14



LTS-11 is not strong Bi-Simulated to LTS-12 and LTS-14.

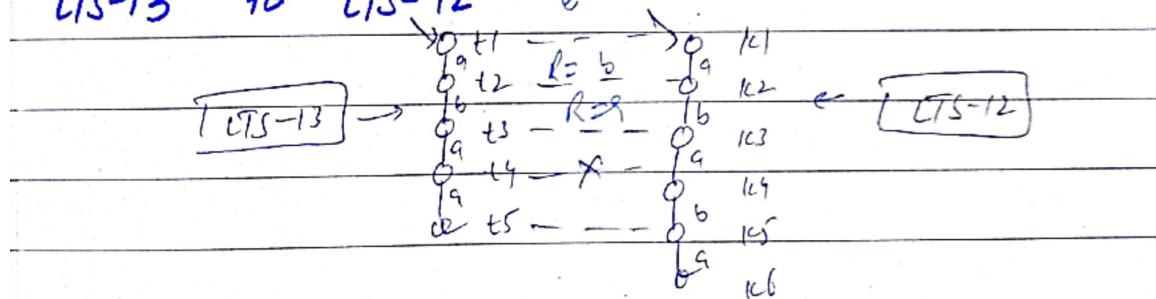
Binding Strong Bi-Simulation For LTS-13

LTS-13 to LTS-15 and LTS-14



LTS-13 is strong equivalent to LTS-15 and not to LTS-11.

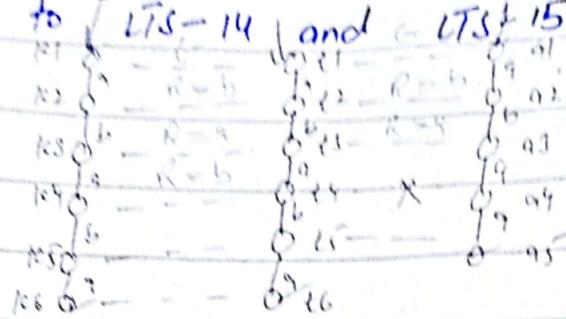
LTS-13 to LTS-12



LTS-13 is not strong bi-simulated to LTS-12.

Finding Strong Bi-Simulation For LTS-12

LTS-12 to LTS-14 and LTS-15

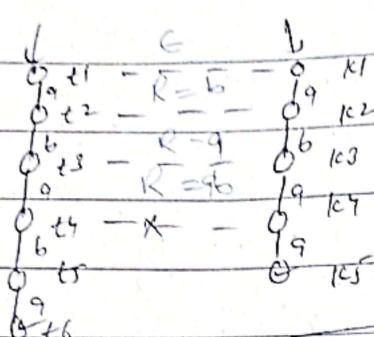


[LTS-14] [LTS-12] [LTS-15]

LTS-12 isn't strong bi-simulated to LTS-15 and strong bi-simulated to LTS-14.

Finding Strong Bi-Simulation For LTS-14.

LTS-14 to LTS-15

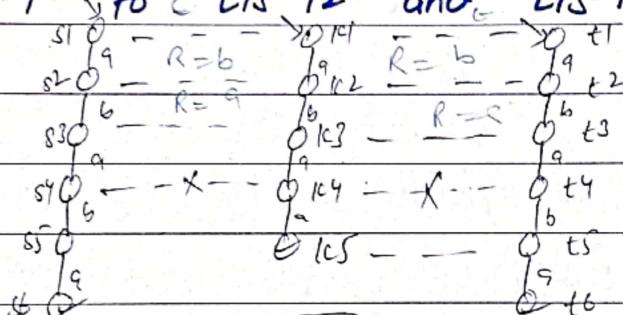


[LTS-14] [LTS-15]

LTS-14 isn't strong bi-simulated to LTS-15.

Remaining Part :-

LTS-1 to LTS-12 and LTS-14



[LTS-14] [LTS-1] [LTS-12]

LTS-1 isn't strong bi-simulated to LTS-12 and LTS-14.

(14)

Introducing Toe's (?)

An action is internal, if we have no way of observing it directly. We use special symbols to denote internal actions.

Internal Action in LTLs.

S-1

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ \overrightarrow{a} \circ$

S-2

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ \overrightarrow{a}$

S-3

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ \overrightarrow{a} \circ$

S-4

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ \overrightarrow{a} \circ$

S-5

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ$

S-6

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ \overrightarrow{a} \circ$

S-8

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ \overrightarrow{a} \circ$

S-7

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ$

S-9

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ \overrightarrow{a} \circ$

S-10

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ$

S-11

$\overrightarrow{a} \circ \overrightarrow{y} \circ \overrightarrow{b} \circ \overrightarrow{a} \circ \overrightarrow{a} \circ$

LTS-12

LTS-13 14

LTS-13

LTS-15

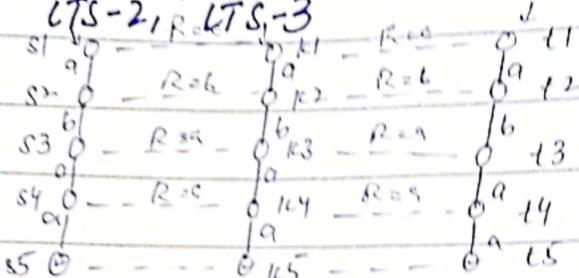
Visible
Visibility

Weak-Bisimulation

Finding Weak Bi-Simulation for LTS-1

To find weak bi-simulation for, we remove ~~to its~~ from
labeled Transition System.

LTS-1 to LTS-2, LTS-3



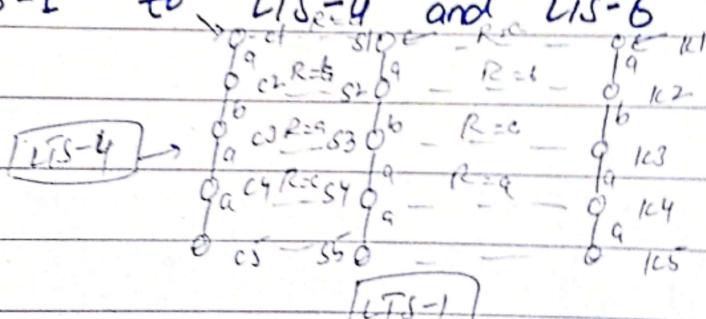
[LTS-3]

[LTS-1]

[LTS-4]

LTS1 is weakly bisimulated to LTS-2 and LTS-3.

LTS-1 to LTS-4 and LTS-6



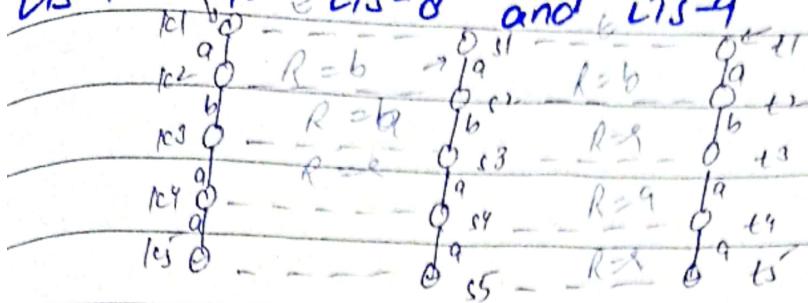
[LTS-4]

[LTS-6]

[LTS-1]

LTS1 is weakly bisimulated to LTS-4 and LTS-6.

LTS-1 to LTS-8 and LTS-9



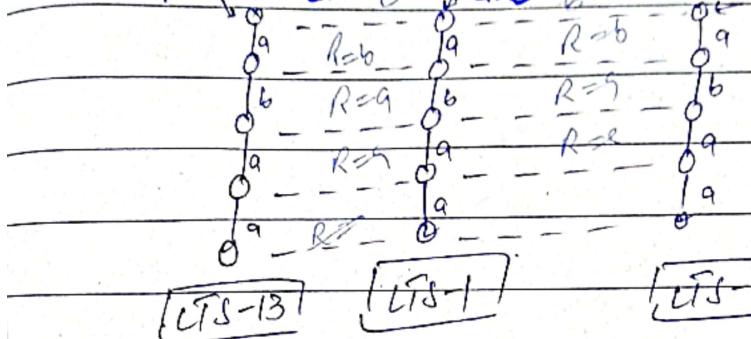
[LTS-8]

[LTS-1]

[LTS-9]

LTS-1 is weak bisimulated to LTS-8 and LTS-9

LTS-1 to LTS-11 and LTS-13



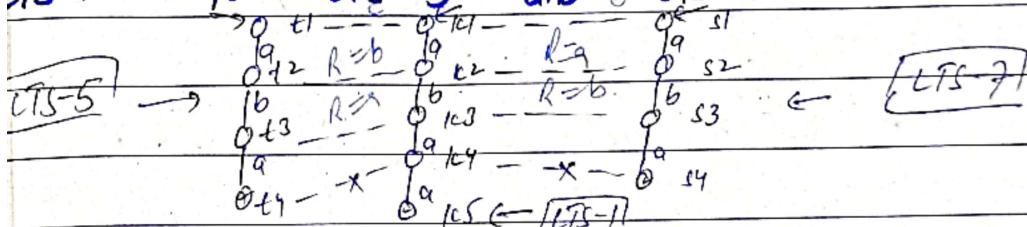
[LTS-13]

[LTS-1]

[LTS-11]

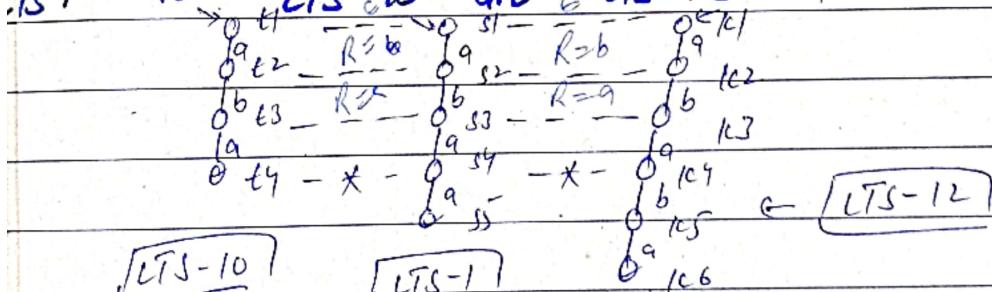
LTS-1 is weak bisimulated to LTS-11 and LTS-13

LTS-1 to LTS-5 and LTS-7



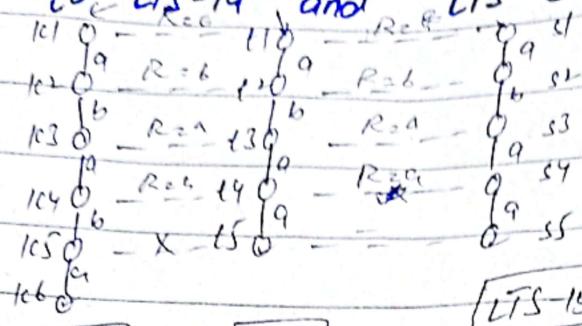
LTS-1 is not weak bisimulated to LTS-5 and LTS-7

LTS-1 to LTS-10 and LTS-12



LTS-1 is not weak bi-simulated to LTS-10 and LTS-12

LTS-1 to LTS-14 and LTS-15



[LTS-14]

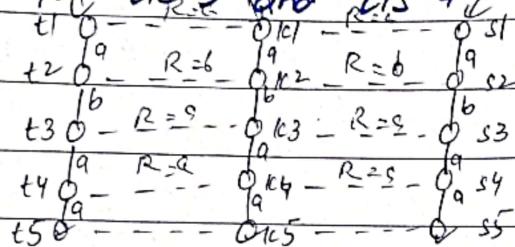
[LTS-11]

[LTS-15]

LTS-1 is weak bi-simulated to LTS-15 and not to LTS-11.

Finding weak Bi-simulation for LTS-2.

LTS-2 to LTS-3 and LTS-4



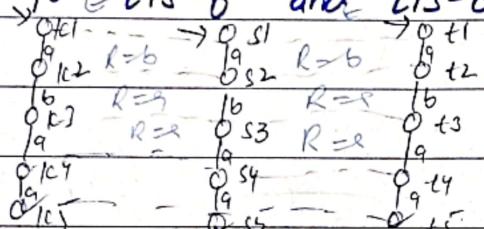
[LTS-3]

[LTS-2]

[LTS-4]

LTS-1 is weak bi-simulated to LTS-2 and LTS-3.

LTS-2 to LTS-6 and LTS-8



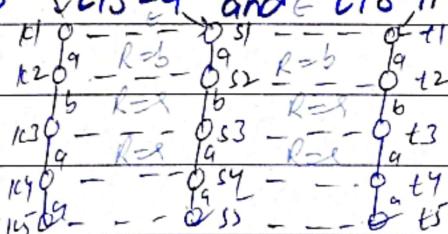
[LTS-8]

[LTS-2]

[LTS-6]

LTS-2 is weak bi-simulated to LTS-6 and LTS-8.

LTS-2 to LTS-9 and LTS-11



[LTS-9]

[LTS-2]

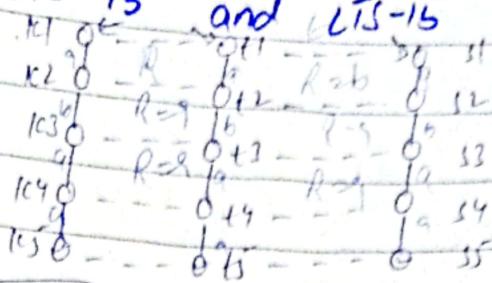
[LTS-11]

LTS-2 is weak bi-simulated to LTS-9 and 11.

(16)

LTS-2 to

LTS-13 and LTS-15



[LTS-13]

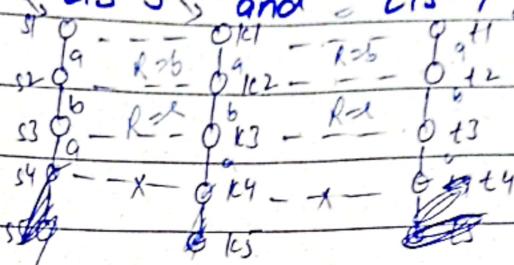
[LTS-2]

[LTS-15]

LTS-2 is weak bi-simulated with LTS-13 and LTS-15.

LTS-2 to

LTS-5 and LTS-7



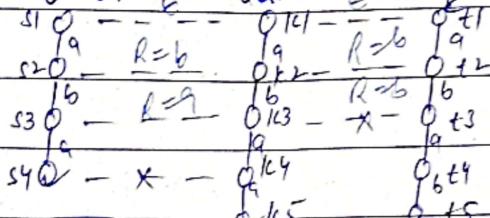
[LTS-5]

[LTS-2]

[LTS-7]

LTS-2 isn't weak bi-simulated to LTS-5 and LTS-7

LTS-2 to LTS-10 and LTS-12



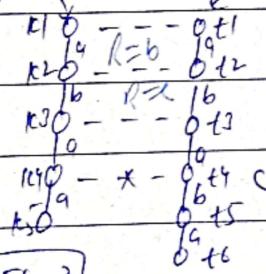
[LTS-10]

[LTS-2]

[LTS-12]

LTS-2 is not weak bi-simulated to LTS-10 and LTS-12.

LTS-2 to LTS-14



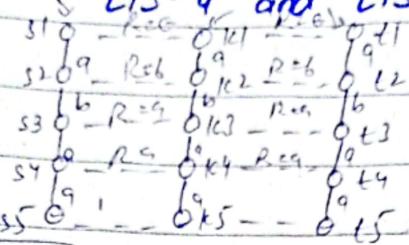
[LTS-2]

[LTS-14]

LTS-2 is not weak bi-simulated to LTS-14.

Finding weak Bi-simulation to LTS-3

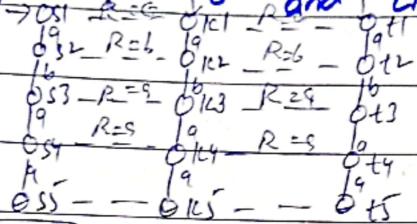
LTS-3 to LTS-4 and LTS-6



LTS-4 LTS-3 LTS-6

LTS-3 is weak bisimulated to LTS-4 and LTS-6.

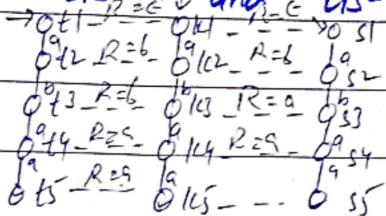
LTS-3 to LTS-8 and LTS-9



T LTS-8 T LTS-3 T LTS-9

LTS-3 is weakly bisimulated to LTS-8 and LTS-9

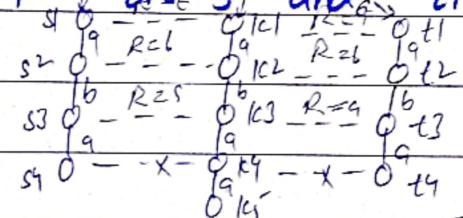
LTS-3 to LTS-11 and LTS-13



LTS-11 LTS-3 LTS-13

CTS-3 is statewide bi-simulated to CTS-11 and CTS-13.

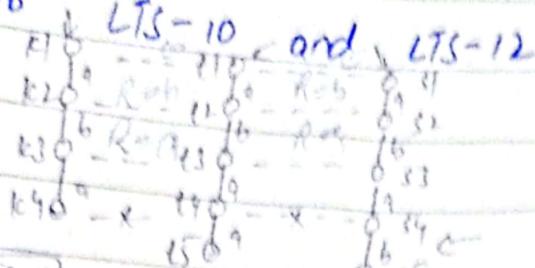
LTS-3 to & LTS-5, and LTS-7



LTS-5 LTS-3 LTS-7

LTS-3 is not weak bi-simulated to LTS-5 and TS-7

LTS-3 to



[LTS-10]

[LTS-3]

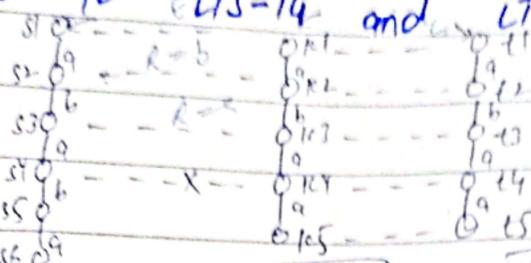
[LTS-12]

[S5]

[S6]

LTS-3 is not weak bi-simulated to LTS-10 and LTS-12.

LTS-3 to LTS-14 and LTS-15



[LTS-14]

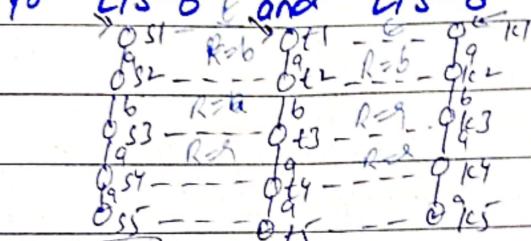
[LTS-3]

[LTS-15]

LTS-3 is weak bi-simulated to LTS-15 and not to LTS-14.

Finding Weak Bi-Simulation For LTS-4

LTS-4 to LTS-6 and LTS-8



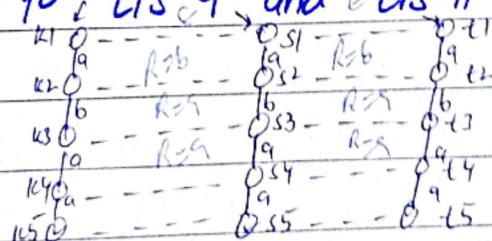
[LTS-6]

[LTS-4]

[LTS-8]

LTS-4 is weak bi-simulated to LTS-6 and LTS-8.

LTS-4 to LTS-9 and LTS-11



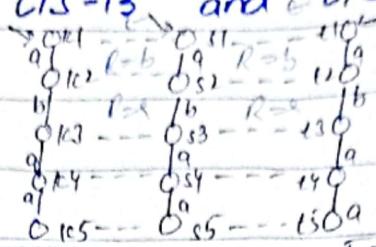
[LTS-9]

[LTS-4]

[LTS-11]

LTS-4 is not weak bi-simulated with LTS-9 and LTS-11.

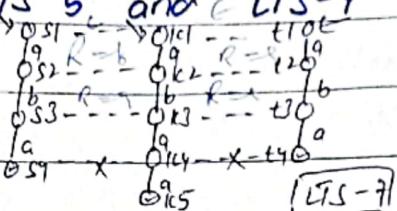
LTS-4 to LTS-13 and LTS-15



[LTS-13] [LTS-4] [LTS-15]

LTS-4 is weak bi-simulated with LTS-13 and LTS-15

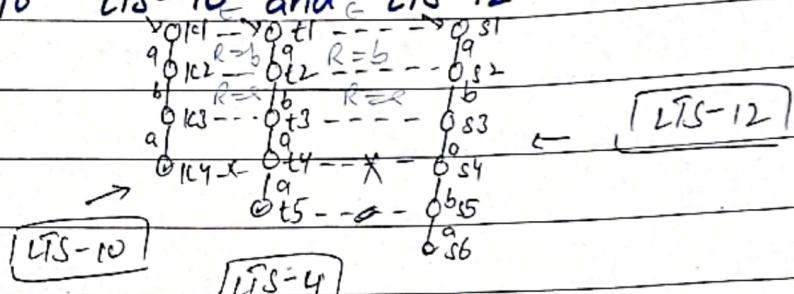
LTS-4 to LTS-5 and LTS-7



[LTS-5] [LTS-4] [LTS-7]

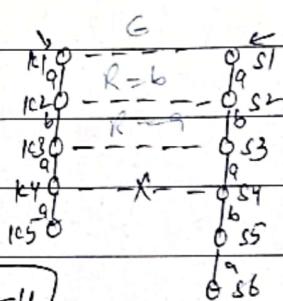
LTS-4 is not weak bi-simulated to LTS-5 and LTS-7

LTS-4 to LTS-10 and LTS-12



LTS-4 is not weak bisimulated to LTS-10 and LTS-12

LTS-4 to LTS-14



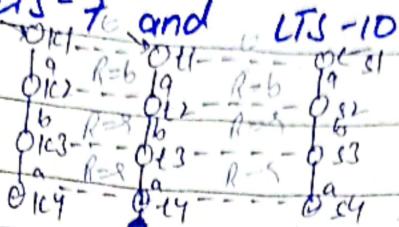
[LTS-4]

[LTS-14]

LTS-4 is not weak equivalent to LTS-14.

(18)

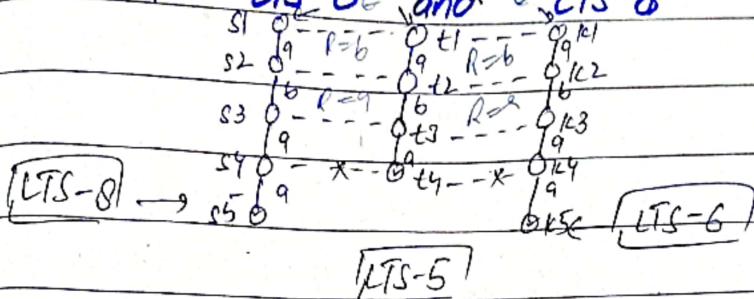
Anding
LTS-5 weak simulation for LTS-5
to LTS-7 and LTS-10



LTS-7 LTS-5 LTS-10

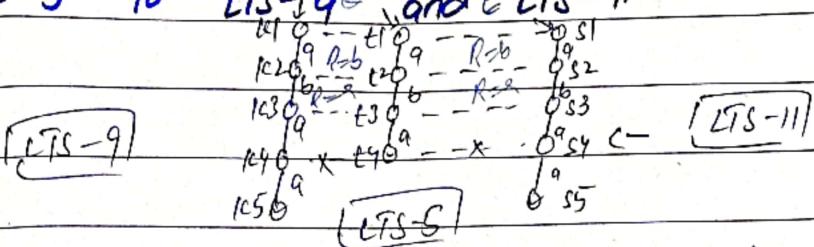
LTS-5 is weak equivalent to LTS-7 and LTS-10.

LTS-5 to LTS-6 and LTS-8



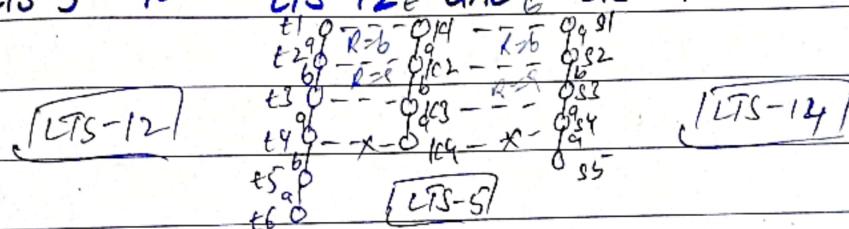
LTS-5 is not weak equivalent to LTS-6 and LTS-8.

LTS-5 to LTS-9 and LTS-11



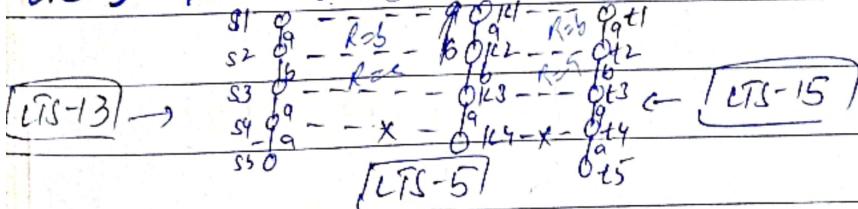
LTS-5 isn't equivalent to LTS-9 and LTS-11.

LTS-5 to LTS-12 and LTS-14



LTS-5 isn't equivalent to LTS-12 and LTS-14.

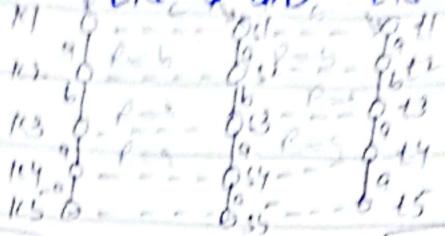
LTS-5 to LTS-15 and LTS-13



LTS-5 is not equivalent to LTS-15 and LTS-13.

Finding weak Bi-Simulation for LTS-6

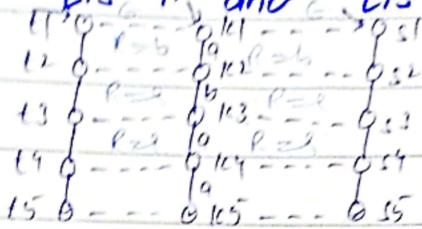
LTS-6 to LTS-8 and LTS-9



[LTS-8] [LTS-6] [LTS-9]

LTS-6 is weak equivalent to LTS-8 and LTS-9.

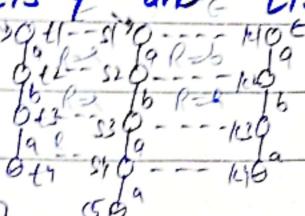
LTS-6 to LTS-11 and LTS-13



[LTS-11] [LTS-6] [LTS-13]

LTS-6 is weak equivalent to LTS-11 and LTS-13.

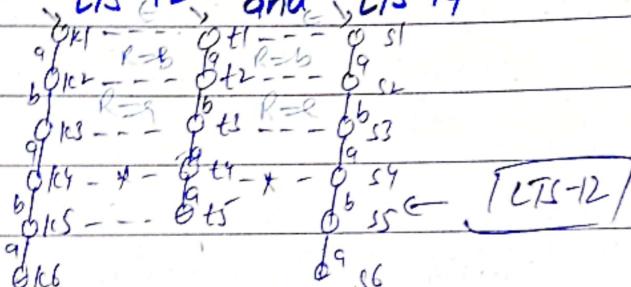
LTS-6 to LTS-7 and LTS-10



[LTS-7] [LTS-6] [LTS-10]

LTS-6 isn't weak equivalent to LTS-7 and LTS-10.

LTS-6 to LTS-12 and LTS-14



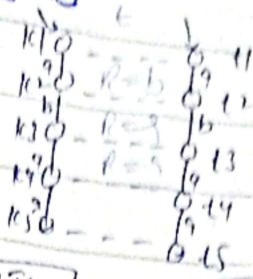
[LTS-6]

LTS-6 isn't weak equivalent to LTS-12 and LTS-14

(19)

LTS-6

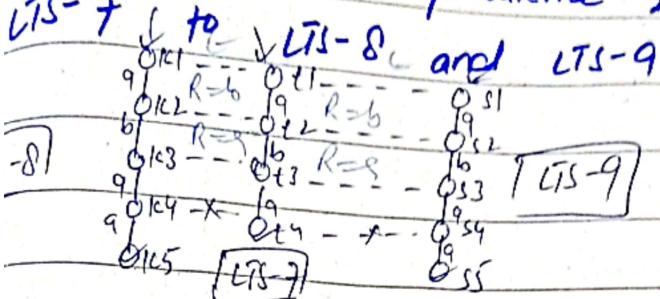
to LTS-15



[LTS-6] [LTS-15]

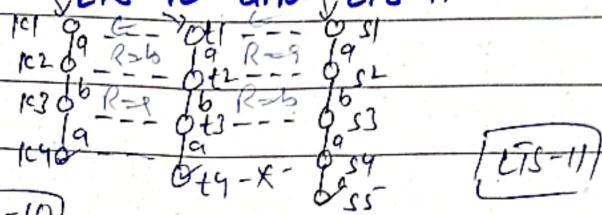
LTS-6 is weakly equivalent to LTS-15.

Binding weak Equivalence for of LTS-7



LTS-7 is not weakly equivalent to LTS-8 and LTS-9.

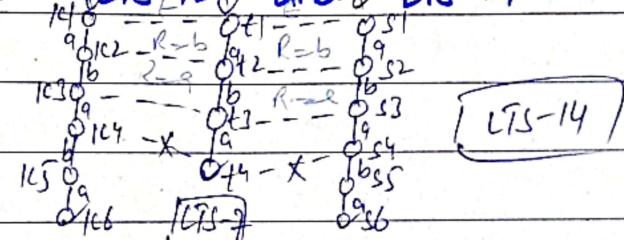
LTS-7 to LTS-10 and LTS-11



[LTS-10] [LTS-7] [LTS-11]

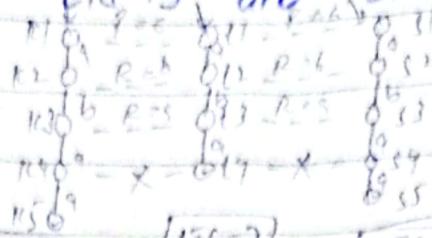
LTS-7 is weakly equivalent to LTS-10, not to LTS-11.

LTS-7 to LTS-12 and LTS-14



LTS-7 is not equivalent to LTS-12 and LTS-14.

LTS-7 to LTS-13 and LTS-15

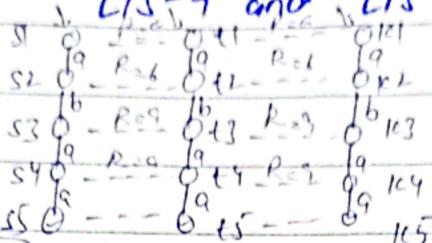


[LTS-13] [LTS-7] [LTS-15]

LTS-7 isn't equivalent to LTS-13 and LTS-15.

Finding weak Bi-Simulation for LTS-8

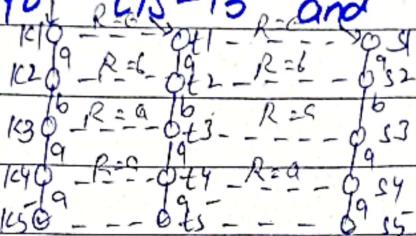
LTS-8 to LTS-9 and LTS-11



[LTS-9] [LTS-8] [LTS-11]

LTS is weakly equivalent to LTS-9 and LTS-11.

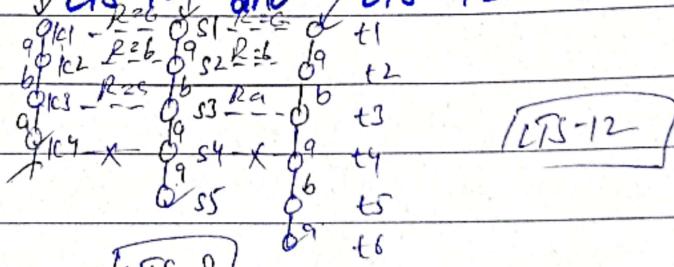
LTS-8 to LTS-13 and LTS-15



[LTS-13] [LTS-8] [LTS-15]

LTS-8 is weakly equivalent to LTS-13 and LTS-15.

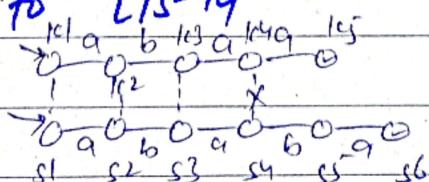
LTS-8 to LTS-10 and LTS-12



[LTS-8]

LTS-8 isn't equivalent to LTS-10 and LTS-12.

LTS-8 to LTS-14



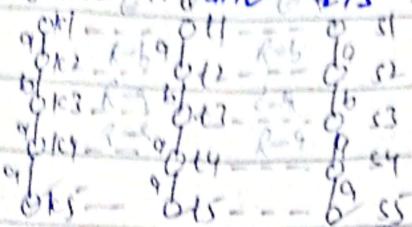
LTS-8 isn't equivalent

to LTS-14.

(20)

Finding weak simulation for LTS-9

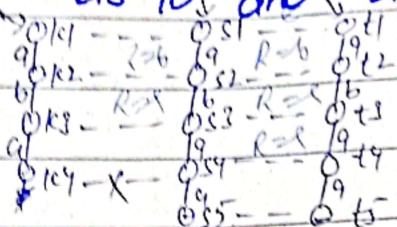
LTS-9 to LTS-11 and LTS-13



[LTS-11] [LTS-9] [LTS-13]

LTS-9 is weak bi-simulated with LTS-11 and LTS-13.

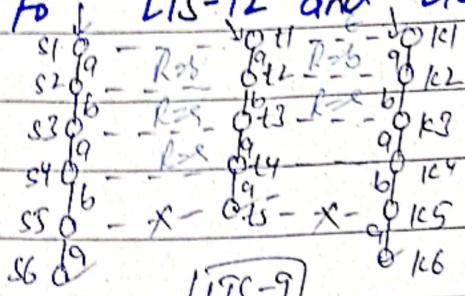
LTS-9 to LTS-10 and LTS-15



[LTS-10] [LTS-9] [LTS-15]

LTS-9 is weak bi-simulated to LTS-15 and not to LTS-10

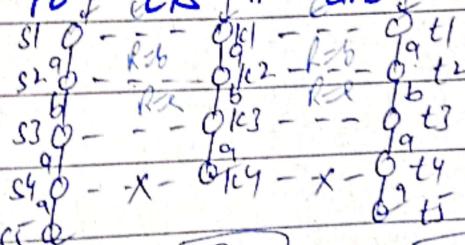
LTS-9 to LTS-12 and LTS-14



LTS-9 isn't equivalent to LTS-12 and LTS-14.

Finding weak & Bi-simulation for LTS-10

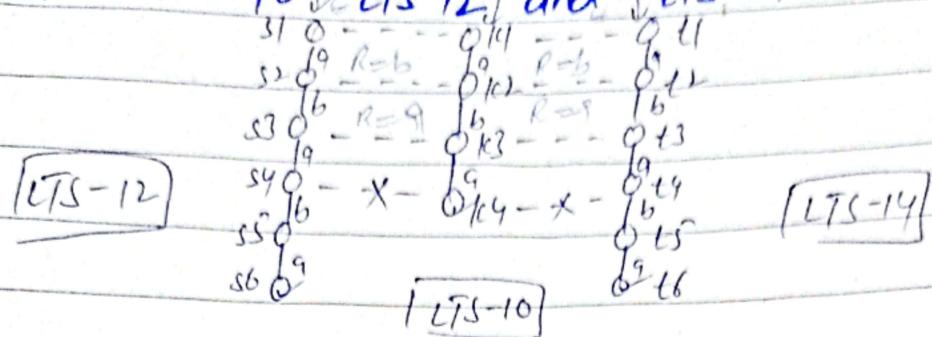
LTS-10 to LTS-11 and LTS-13



[LTS-11] [LTS-10] [LTS-13]

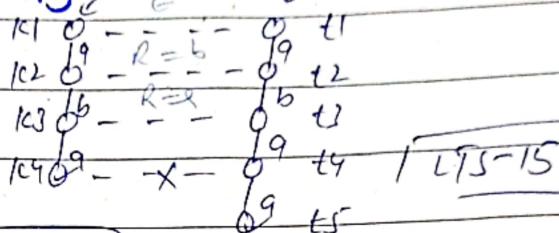
LTS-10 isn't weak bi-simulated to LTS-11 and LTS-13.

LTS-10 to LTS-12 and LTS-14



LTS-10 isn't weak bi-simulated to LTS-12 & LTS-14.

LTS-10 to LTS-15

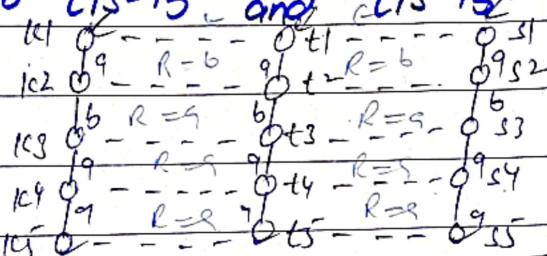


LTS-10

LTS-10 isn't weak bi-simulated to LTS-15.

Finding Weak Bi-simulation to LTS-11.

LTS-11 to LTS-13 and LTS-15



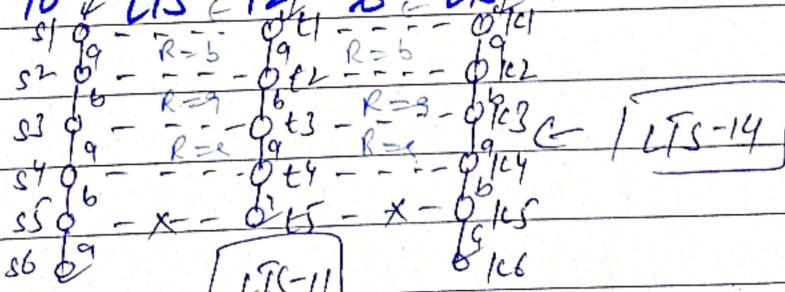
LTS-13

LTS-11

LTS-15

LTS-11 is weak bi-simulated to LTS-13 & LTS-15.

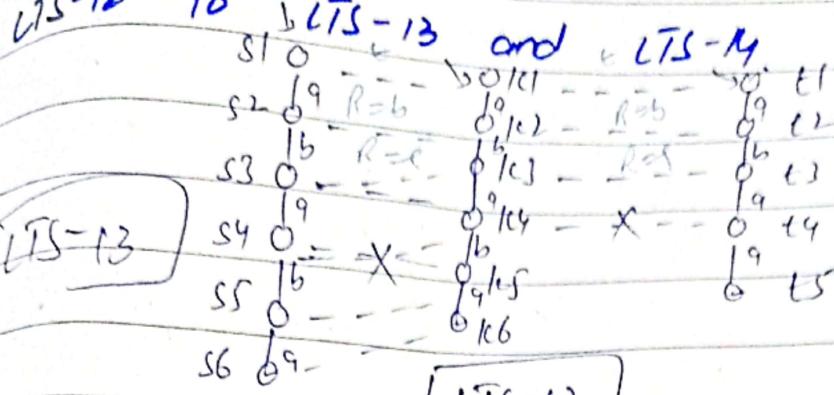
LTS-11 to LTS-12 & LTS-14



LTS-11 isn't weak bi-simulated to LTS-12 & LTS-14.

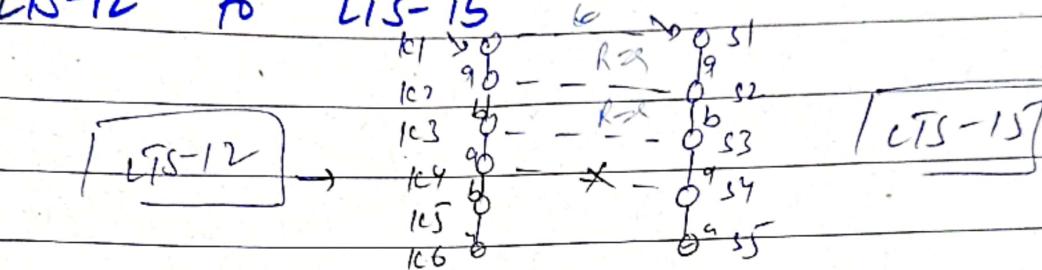
(2)

Finding Weak Bi-Simulation For LTS-12.



LTS-12 is weak bi-simulated to LTS-13 and not to LTS-14

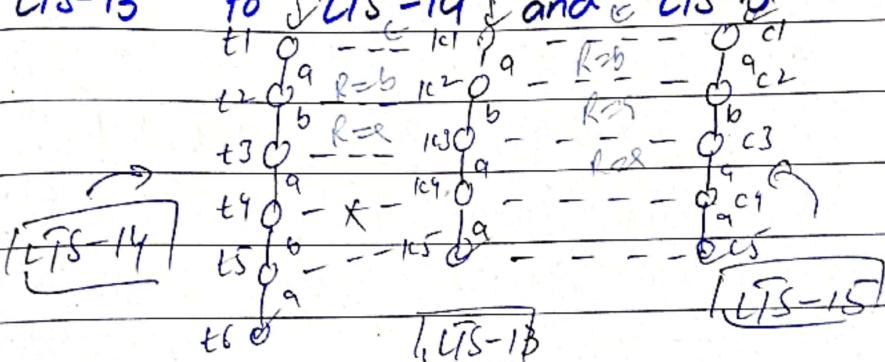
LTS-12 to LTS-15



LTS-12 is not weak bi-simulated to LTS-15.

Finding Weak Bi-Simulation For LTS-13

LTS-13 to LTS-14 and LTS-15



LTS-13 is weak bi-simulated to LTS-15 and not to LTS-14.