# Exercise
# for Lecture “P2P Systems”

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**Exercise No. 9**
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**Submission only via the Moodle platform in PDF, plain text, or JPG/PNG.**
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**– Example Solution –**

## Problem 9.1 - PlanetLab

A) Choose the right answer:

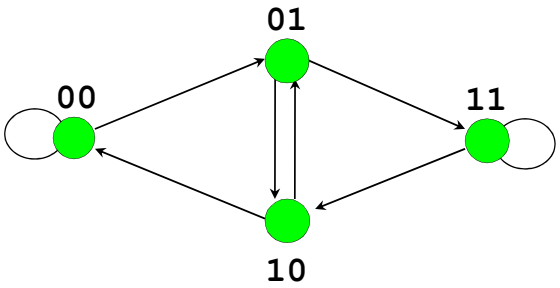
| | | TRUE | FALSE |
|---|---|---|---|
| i) | PlanetLab is based on Xen technology. | ☐ | ☒ |
| ii) | An institution may join PlanetLab only if it supplies more than 2 nodes. | ☐ | ☒ |
| iii) | Each user having a PlanetLab account may use all PlanetLab nodes at once. | ☒ | ☐ |
| iv) | PlanetLab supports various operating systems (e.g. Windows and Linux). | ☐ | ☒ |
| v) | PlanetLab is a suitable platform to evaluate P2P algorithms and protocols. | ☒ | ☐ |

B) What is the difference between Planet Lab slices and slivers?

**Solution:** Sliver => A virtual resource (e.g. a virtual machine). Slice => A set of virtual resources (slivers), e.g. a virtualized Chord network.

## Problem 9.2 - de Brujin Networks

A) Consider the following de Brujin network with 4 nodes. Now the network size should be increased to the next smallest size. Provide an algorithm for this construction step and draw the resulting network.

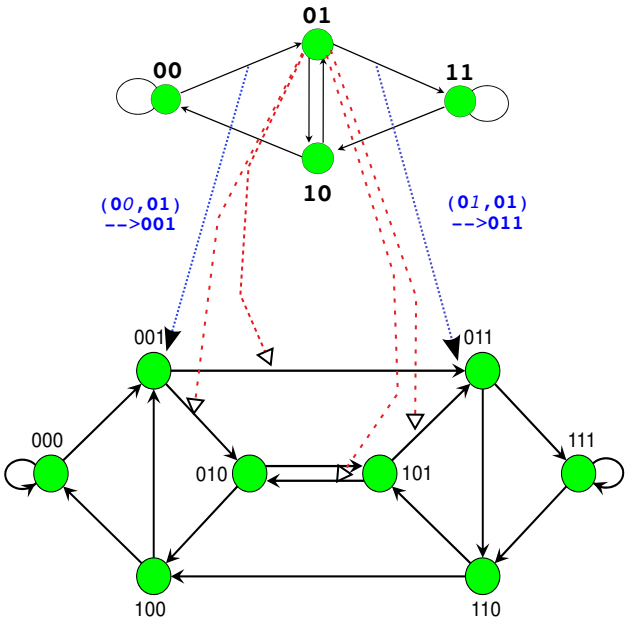



**Solution:** The next smallest possible network consists of 8 nodes ($2^n > 4$). The exact construction rules are defined on lecture slides. A more informal description works as follows:

A) Replace each edge with a node by merging the first bit of the source node with the bit string of the target node (e.g. `00` and `01` results in `001`).

B) For each *old* node: create for *each pair of incoming and outgoing edges* a *new edge* by replacing the edges with the nodes generated by the previous rule (e.g. for the old node `01` there will be 4 new edges `(001,011)`, `(001,010)`, `(101,011)`, and `(101,010)`

Selected transitions are shown in the figure below. Blue dotted arrows demonstrate the rule 1, and red dashed arrows – the rule 2.




B) One problem with (binary) de Brujin networks is that their size is limited to powers of 2. Now consider the case that a network has a different size $m$ with $2^{n-1} < m < 2^n$ for some

$n$. Please provide at least two approaches how to construct a de Brujin network in this case and discuss benefits and drawbacks of both solutions.

**Solution:**

1. Approach: **incomplete graph** – requires restricted routing, must assure that all nodes are still connected (despite asymmetric links).

2. Approach: **virtual nodes** – e.g. $2^n - m$ nodes must obtain two IDs and therefore two routing tables. Quite flexible approach with possible routing optimizations for nodes hosting multiple virtual nodes. However, possible issues with load balancing and additional overhead for virtual node assignment.