University of Konstanz
Department of Computer & Information Science
PD Dr. Sven Kosub / Mehwish Nasim

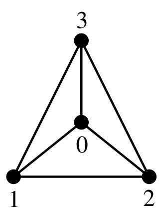
Network Dynamics
Winter 2013/14

# Assignment 3

**Ausgabe:** 6 Nov 2013 **Abgabe:** 13 Nov 2013

## Problem 1: Fixed-point analysis — 10 Points

Consider the following AS graph together with total orderings of all path sets:




$$\begin{array}{lcl} P^0 & : & (0) \succ_0 \varepsilon \\ P^1 & : & (1,0) \succ_1 (1,2,0) \succ_1 (1,3,0) \succ_1 (1,3,2,0) =_1 (1,2,3,0) \succ_1 \varepsilon \\ P^2 & : & (2,3,0) \succ_2 (2,1,0) \succ_2 (2,1,3,0) \succ_2 (2,3,1,0) \succ_2 (2,0) \succ_2 \varepsilon \\ P^3 & : & (3,1,0) \succ_3 (3,1,2,0) \succ_3 (3,0) \succ_3 (3,2,0) \succ_3 (3,2,1,0) \succ_3 \varepsilon \end{array}$$

The AS graph is oriented according to customers and providers for each node. Note that a directed edge $u \to v$ indicates that $u$ is a customer of $v$, and a directed edge $u \leftarrow v$ indicates that $u$ is a provider of $v$.

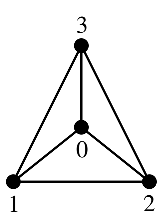
(a) Eliminate all paths from the paths sets that are not valley-free.

(b) Determine all customer paths in the remaining path sets.

(c) Is the Gao-Rexford convergence criterion satisfied for the remaining BGP system? If your answer is "yes", what is the number of iterations need to reach a fixed point?

## Problem 2: Best-response dynamics — 10 Points

Consider the following AS graph together with the preference ordering of all path sets:




$$\begin{array}{lcl} P^0 & : & (0) \succ_0 \varepsilon \\ P^1 & : & (1,2,0) \succ_1 (1,0) \succ_1 (1,3,0) =_1 (1,2,3,0) =_1 (1,3,2,0) \succ_1 \varepsilon \\ P^2 & : & (2,3,0) \succ_2 (2,0) \succ_2 (2,1,0) =_2 (2,1,3,0) =_2 (2,3,1,0) \succ_2 \varepsilon \\ P^3 & : & (3,1,0) \succ_3 (3,0) \succ_3 (3,2,0) =_3 (3,1,2,0) =_3 (3,2,1,0) \succ_3 \varepsilon \end{array}$$

Suppose that an initial configuration is

$$\pi(0) = 0, \quad \pi(1) = (1,2,3,0), \quad \pi(2) = (2,3,0), \quad \pi(3) = (3,0).$$

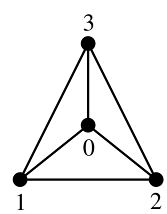
How many update steps are needed to obtain the same configuration again, if the nodes update their best paths simultaneously?

Note that for each node only the edge to next hop on the best path is used to build the routing network.

**Problem 3: Best-response dynamics** **10 Points**

A configuration $\pi$ is said to be a *fixed-point configuration* if and only if $\pi = \pi'$ where $\pi'$ is the configuration obtained when all nodes simultaneously update their best paths given $\pi$.

Consider again the following AS graph $G = (V, E)$:




If possible, design a total ordering of the path sets $P^0, P^1, P^2$, and $P^3$ such that

(a) there is a fixed-point configuration $\pi_{\text{fix}}$ and

(b) there is an initial configuration $\pi_{\text{init}}$ such that $\pi_{\text{fix}}$ is never reached assuming that all nodes updates their best paths simultaneously

Note that for each node only the edge to next hop on the best path is used to build the routing network.