Sync: Towards Congestion Control based on Emergent Behaviour

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I. EXTENDED ABSTRACT

Computer networks have experienced an explosive growth over the past decade As a side effect of this grow in 1986 the internet had the first of what became a series of 'congestion collapses'. A network is considered as congested when too many packets arrive at the same router's queue, resulting in an amount of packets being dropped. To avoid a congestion collapse congestion control is essential. Most of the work on congestion control concentrates on algorithms trying to identify which packets should be dropped preferentially. However, for a more satisfying solution traffic should be routed along paths with sufficient capacity if possible. Such a strategy requires close interaction between congestion control and routing. While from the perspective of the traditional Internet this corresponds to a violation of the layer principle, for a future Internet such strict rules seem no longer be appropriate.

To reduce management and configuration complexity of a congestion control coupled with routing we put a strong emphasis self-organisation based on emergent behaviour. One example for emergent behaviour is the spontaneous phase synchronization of pulse-coupled oscillators, which is a well known phenomenon in biology and physics [1][2]. During the talk we focus on the oscillators model as introduced by Mirollo and Strogatz in [1]. In their model a single oscillator is characterized by a concave status function f(t). For t growing from 0 to T, the function f describes the charging of the oscillator up to a maximum voltage $V_{MAX}=f(k*T)$ (k=1,2,3,…). In case an oscillator is charged up to V_{MAX} it sends a pulse of energy to all oscillators in its environment (i.e. it fires), sets it charging level to 0 and starts again the charging process. At the same time, the energy emitted increases the charging of each other oscillator by a predefined amount ε, shown in the right side of **Fehler! Verweisquelle konnte nicht gefunden werden.**

A result of the work of Mirollo and Strogatz is that each group of identical, pulse-coupled oscillators following their model reaches a state where they have synchronized their phases (up to a set of measure zero). An application of this synchronisation property to networking problems is of interest because of the following reasons:

1. No additional configuration or management is required.
2. Once archived, synchronicity corresponds to a stable equilibrium.

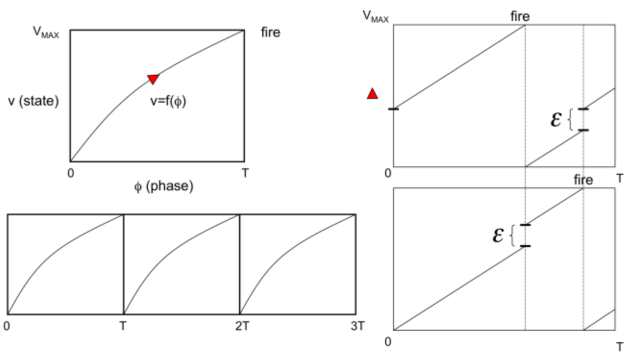

Figure 1. Oscillator Model

Recent research in the networking area has investigated in the question if pulse coupled oscillators can be used e.g. for time synchronisation in Ad-Hoc or sensor networks [3][4]. In contrast to this work we focus on the question:

"Can pulse-coupled oscillators be used for congestion control in IP-based networks?"

In the talk we will address this question in the context of Multi Path Routing.

[1] C. S. Peskin, Mathematical Aspects of Heart Physiology Courant Institute of Mathematical Sciences, New York University, New York (1975): pp. 268-278

[2] R. E. Mirollo and S. H. Strogatz. Synchronization of pulse-coupled biological oscillators. SIAM Journal on Applied Mathematics, 50(6):16451662, December 1990

[3] A. Tyrrell, G. Auer, C. Bettstetter, "Firefly Synchronization in Ad Hoc Networks", MINEMA workshop, 2006

[4] Y. W. Hong, A. Scaglione, "A scalable synchronization protocol for large scale sensor networks and its applications," IEEE Journal on Selected Areas in Communications, pp. 1085–1099, May 2005.