COINC Library : A toolbox for Network Calculus.

Anne Bouillard[*], Bertrand Cottenceau[†], Bruno Gaujal[‡], Laurent Hardouin, Sebastien Lagrange, Mehdi Lhommeau, Eric Thierry[§]

This talk will present the Scilab toolbox for Network Calculus computation. It was developed thanks to the INRIA ARC COINC project (COmputational Issue in Network Calculus see `http://perso.bretagne.ens-cachan.fr/~bouillar/coinc/spip.php?rubrique1`). This software library deals with the computation of ultimate pseudo-periodic functions. They are very useful to compute performance evaluation in network (e.g. Network Calculus) or in embedded system (Real Time Calculus).

Each function f is composed of segments characterized by (x, y, y^+, ρ, x_n) (see figure 1), arranged in two lists of segments denoted p and q and with a segment denoted r, it is denoted : $f = p \oplus qr^*$. List p is composed of segments which depict a transient behavior, list q is composed of segments which represent a pattern repeated periodically, segment r is a point representing the periodicity of function f (see figure 1). The formulation is inspired by the one of periodical series in the idempotent semiring of formal series such as introduced in [1], and which have is own Scilab toolbox called Minmaxgd [5] based on algorithms proposed in [6] and in [4], [7]. The COINC toolbox yields six operations handling ultimately pseudo periodic function (uppf), namely

- The minmium of two uppf (the sum in the $(min, +)$ setting) :

$$p \oplus qr^* = (p_1 \oplus q_1 r_1^*) \oplus (p_2 \oplus q_2 r_2^*)$$

- The (min-+) convolution of two uppf (product of two uppf) :

$$p \oplus qr^* = (p_1 \oplus q_1 r_1^*) \otimes (p_2 \oplus q_2 r_2^*)$$

[*]ENS Cachan/IRISA, Campus de Ker Lann, 35170 Bruz (France)

[†]B. Cottenceau, L. Hardouin, S. Lagrange and M. Lhommeau, are with the Angers University/LISA/ISTIA, 62 avenue Notre Dame du Lac, 49000 Angers (France)

[‡]INRIA/LIG, 51, av Kuntzman, 38330 Montbonnot (France)

[§]ENS Lyon/IXXI, 46, allée d'Italie, 69007 Lyon (France)

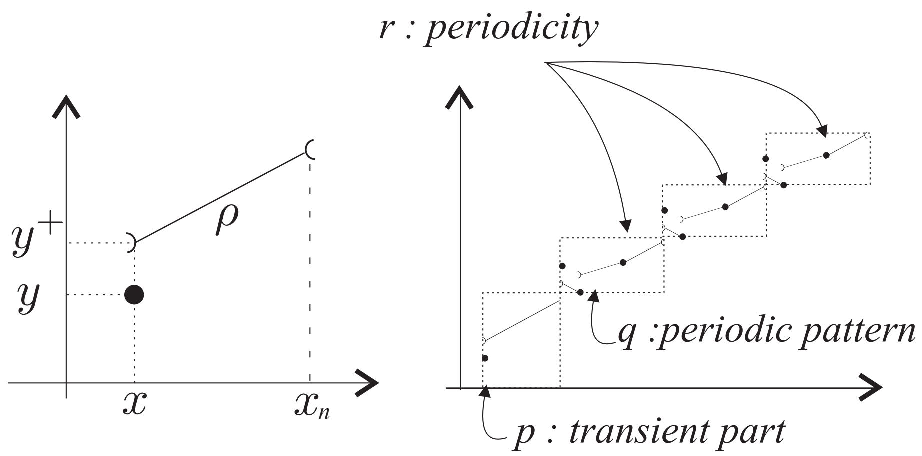

FIGURE 1 – A monomial (a point (x, y) and a segment starting in (x, y^+) with a slope equal to ρ and ending in x_n) and an uppf function ($f = p \oplus qr^*$).

- The (min,+) deconvolution of two uppf (residuation of two uppf) :

$$p \oplus qr^* = (p_1 \oplus q_1 r_1^*) \phi (p_2 \oplus q_2 r_2^*)$$

- The addition of two uppf (The Hadamard product of two uppf) :

$$p \oplus qr^* = (p_1 \oplus q_1 r_1^*) \odot (p_2 \oplus q_2 r_2^*)$$

- The subaddditive cloture (The Kleene star of an uppf) :

$$p \oplus qr^* = ((p_1 \oplus q_1 r_1^*))^*$$

The software is based on algorithms given in [2], and also in [6], [4] and [7], it is available as a Scilab contribution and on the following url `http:\\www.istia.univ-angers.fr\~lagrange\COINC`.

During the talk some illustrations about Network Calculus (see [8],[3]) will be proposed including all those operations. Let just recall that an arrival curve is a segment $(0, \sigma, \sigma, \rho, +\infty)$ with σ the burst and ρ the arrival rate, and a service curve is represented by a list of two segments $m_1 \oplus m_2$ with $m_1 = (0, 0, 0, 0, \tau)$ and $m_2 = (\tau, 0, 0, \theta, +\infty)$ with τ the delay and θ the service rate.

Références

[1] F. Baccelli, G. Cohen, G.J. Olsder, and J.P. Quadrat. *Synchronization and Linearity : An Algebra for Discrete Event Systems*. Wiley and Sons, 1992.

[2] A. Bouillard and E. Thierry. Optimal routing for end-to-end guarantees : the price of multiplexing. *Discrete Event Dynamic Systems*, 18 :3–49, 2008. `http://perso.bretagne.ens-cachan.fr/~bouillar/coinc`.

[3] C.S. Chang. *Performance Guarantees in Communication Networks*. Springer, 2000.

[4] B. Cottenceau. *Contribution à la commande de systèmes à événements discrets : synthèse de correcteurs pour les graphes d'événements temporisés dans les dioïdes*. Thèse, LISA - Université d'Angers, 1999.

[5] B. Cottenceau, L. Hardouin, M. Lhommeau, and J.-L. Boimond. Data processing tool for calculation in dioid. In *WODES'2000, Workshop on Discrete Event Systems*, Ghent, Belgique, Août 2000.

[6] S. Gaubert. *Théorie des Systèmes Linéaires dans les Dioïdes*. Thèse, École des Mines de Paris, July 1992.

[7] L. Hardouin, B. Cottenceau, and M. Lhommeau. Minmaxgd a library for computation in semiring of formal series. *http ://www.istia-angers.fr/~hardouin/outils.html.*, 2006.

[8] J.Y. Le Boudec and P. Thiran. *Network calculus : a theory of deterministic queuing systems for the internet*. Springer, 2001. `http://ica1www.epfl.ch/PS_files/netCalBookv4.pdf`.