A Fluid Approach for Evaluating The Performance of TCP Traffic in the Presence of Real Time Traffic

Mohamed El Hedi Boussada **Mounir Frikha** **Jean Marie Garcia**

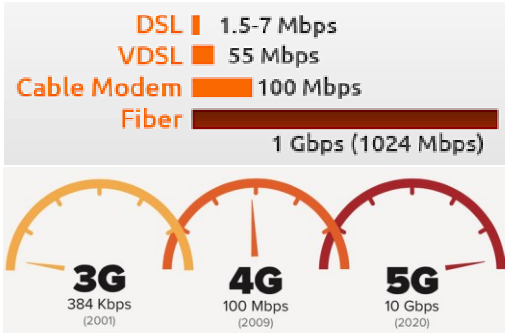
6th International Conference on Communications and Networking ComNet'2017

Hammamet, Tunisia, Marth 29th – April 1st, 2017

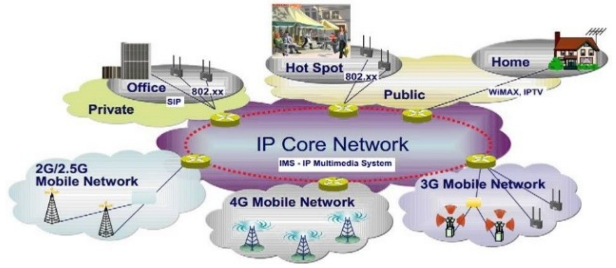
PLAN

1. Introduction
2. Model and Analysis
3. Simulations and validity of results
4. Conclusion

Increase in mobile communications



Growth in access rates



Convergence of access technologies

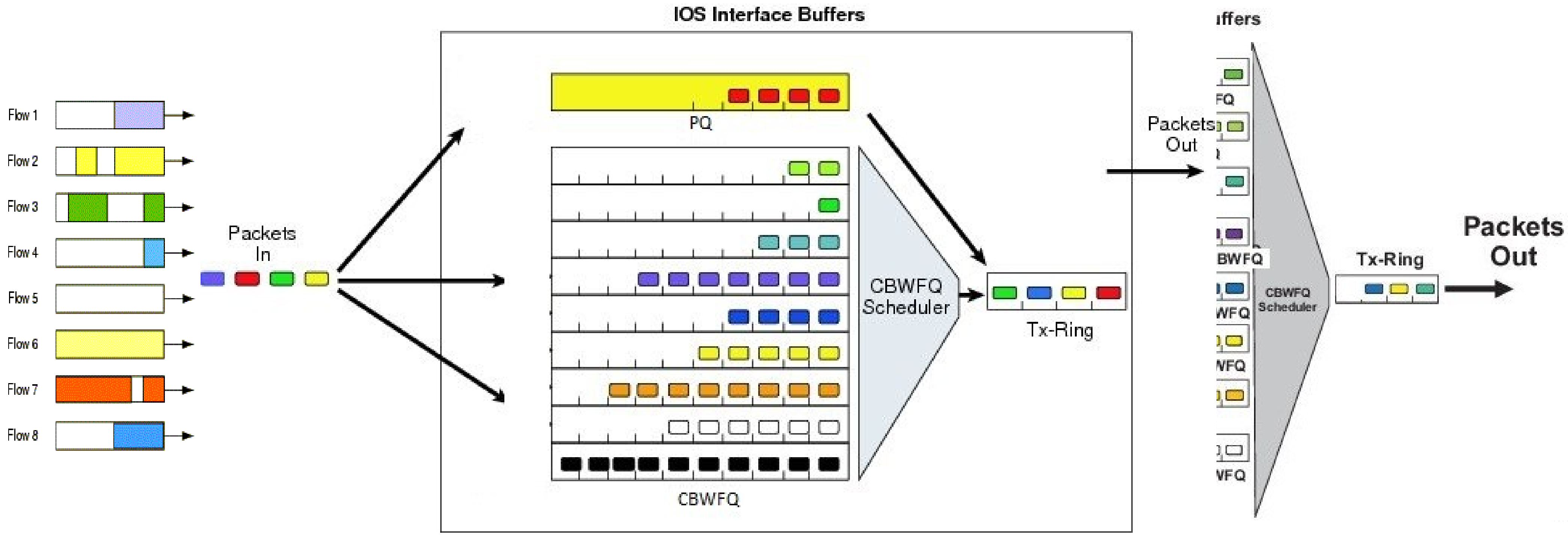
Exponential growth in the number of Internet users

Multiplication of services

Growth in the generated traffic


Elastic and Inelastic Traffic
can adjust to delay and throughput changes across an internet
-traditional "data" style TCP/IP traffic
does not easily adapt to changes in delay and throughput
-"real-time" traffic such as voice and video
Elastic Traffic
Inelastic Traffic

Differentiation of services: several scheduling policies



Priority Queueing

Class-Based Weighted Fair Queueing

Low Latency Queueing

The interruption of services and the deterioration of the quality of service are now becoming less and less tolerable.

↓

Ensuring the continuity and quality of services is the main challenge for network operators.

↓

Operators must anticipate the degradation of quality of service using traffic engineering techniques.

↓

Analytical models, theoretical methods and tools suitable for predicting and controlling the quality of service of the flows.

Two level of traffic modelling

Packet Level

- It defines how packets are generated and routed during communication.
- It incorporates many details about the system.
- It usually considers a fixed number of persistent flows.

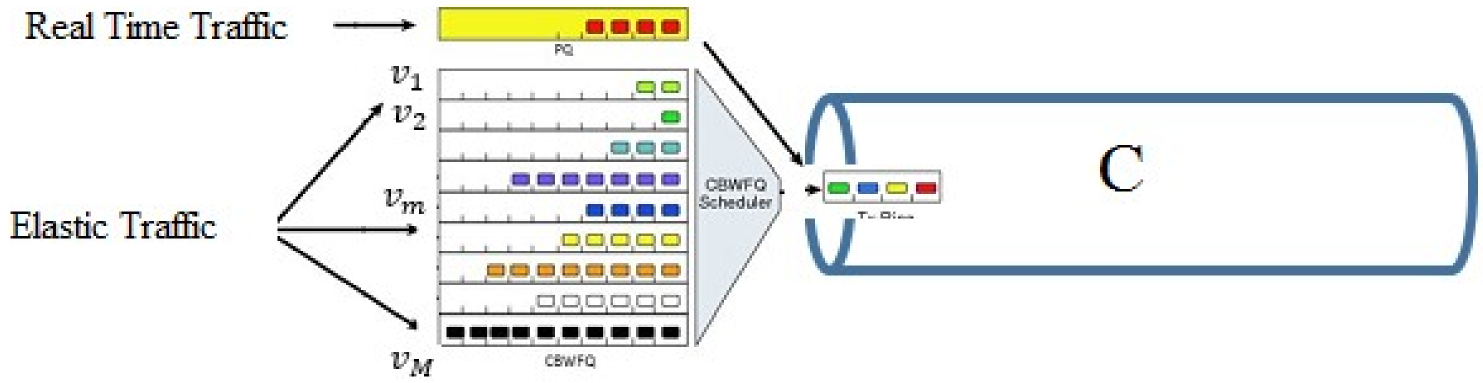
Flow Level

- Ignores complex packet level mechanisms.
- It takes into account the random dynamics of flows
- Uses very simple models of bandwidth sharing.

Objectives

- **Present a fluid model to study a LLQ system taking into account the coupling aspect between the CBWFQ queues.**
- **Exploit proven results for a Best Effort system to analyze the CBWFQ system.**

System Model



E: The set of elastic classes flows / S: The set of real time classes flows

Poisson arrival of flows with rate $\lambda_i^{(e)}$ $\forall\, i \in E$ and $\lambda_j^{(s)} \forall\, j \in S$ (***Flows/Second***)

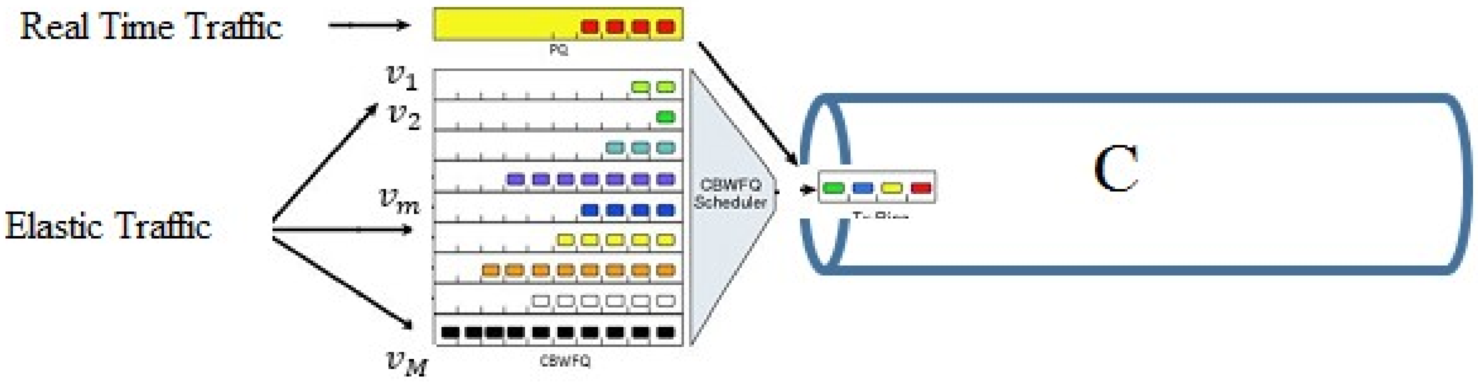
σ_i(***Mbits/flow***): The average file size transferred by an elastic flow

τ_j(***Second***): The average duration of an real time flow

$d_j^{(s)}$(***Mbits/Second***): The rate of each real time flow (**constant**) of class j $\in S$.

$d_i^{(e)}$ (***Mbits/Second***): The maximum rate of an elastic flow of class $i \in E$: $d_i^{(e)}$=d $\forall\, i \in E$

System Model



$\rho_i^{(e)} = \lambda_i^{(e)} \sigma_i(\mathbf{Mbits/Seconde})$: The load of the elastic class *i*.

$\rho_j^{(s)} = \lambda_j^{(s)} \tau_j(\boldsymbol{Flows})$: The load of the real time class *j*

$\theta^{(e)} = \sum_{i \in E} \rho_i^{(e)}$: The mean elastic traffic generated.

$\theta^{(s)} = \sum_{j \in S} \rho_j^{(e)}$: The mean real time traffic generated

$\theta^{(e)} + \theta^{(s)} < \mathbf{C}$

Average throughput:

$\gamma_i = \frac{\rho_i^{(e)}}{E_i}$

E_i: The average number of flows for elastic class i

Quasi-stationary assumption

$$\frac{\lambda_j^{(s)}}{\lambda_i^{(e)}} \ll 1 \quad \forall i \in E, \forall j \in S$$

Let n the quantity of the capacity C used by real time flows.

The remaining capacity for elastic traffic : $C^{(e)}(n) = C - n$

The average throughput for each queue m is then given by: $\gamma_m = \sum_n \gamma_m(n)\, A(n)$

$$\gamma_m(n) = \frac{\theta_m^{(e)}}{E_m^{WFQ}(n)}$$

$\theta_m^{(e)}$: The elastic offered traffic to the queue m

E_m^{WFQ}: The average number of flows for the CBWFQ queue num

Analysis of the CBWFQ system

Numerical approximation:

$$E_m^{CBWFQ} = \frac{a}{(v_m)^{\alpha} + b} + c$$

Key numerical result:

$$E^{BE} = E^{CBWFQ}$$

Key proven results:

$$E^{BE} = \frac{\theta^{(e)}}{d} + B\frac{\theta^{(e)}}{C - \theta^{(e)}}$$

$$E_i^{BE} = \frac{\rho_i^{(e)}}{\theta^{(e)}} E^{BE}$$

Analysis of the CBWFQ system

$$v_m \to 1 \qquad E^{WFQ}_{m|v_m \to 1} = E^{BE}{}_{\theta^{(e)}=\theta^{(e)}_m}$$

$$v_m \to 1/M \qquad E^{WFQ}_{m|v_m \to 1/M} = \frac{\theta^{(e)}_m}{\theta^{(e)}} E^{BE}$$

$$v_m \to 0 \qquad E^{WFQ}_{m|v_m \to 0} = E^{BE} - E^{BE}{}_{\theta^{(e)}=\theta^{(e)}-\theta^{(e)}_m}$$

$$a = (E^{BE}_m - c)\left(\left(\frac{1}{M}\right)^3 + b\right)$$

$$b = \frac{E^{BE}_m - E^{WFQ}_{m/\vartheta_m \to 1}}{(M^3-1)\left(E^{WFQ}_{m|v_m \to 0} - E^{BE}_m\right) - \left(E^{BE}_m - E^{WFQ}_{m/\vartheta_m \to 1}\right)}$$

$$c = E^{BE}_m - \frac{1+b}{1-(1/M)^3}\left(E^{BE}_m - E^{WFQ}_{m/\vartheta_m \to 1}\right)$$

α is adjusted numerically to 3

Testing our approximation for CBWFQ system

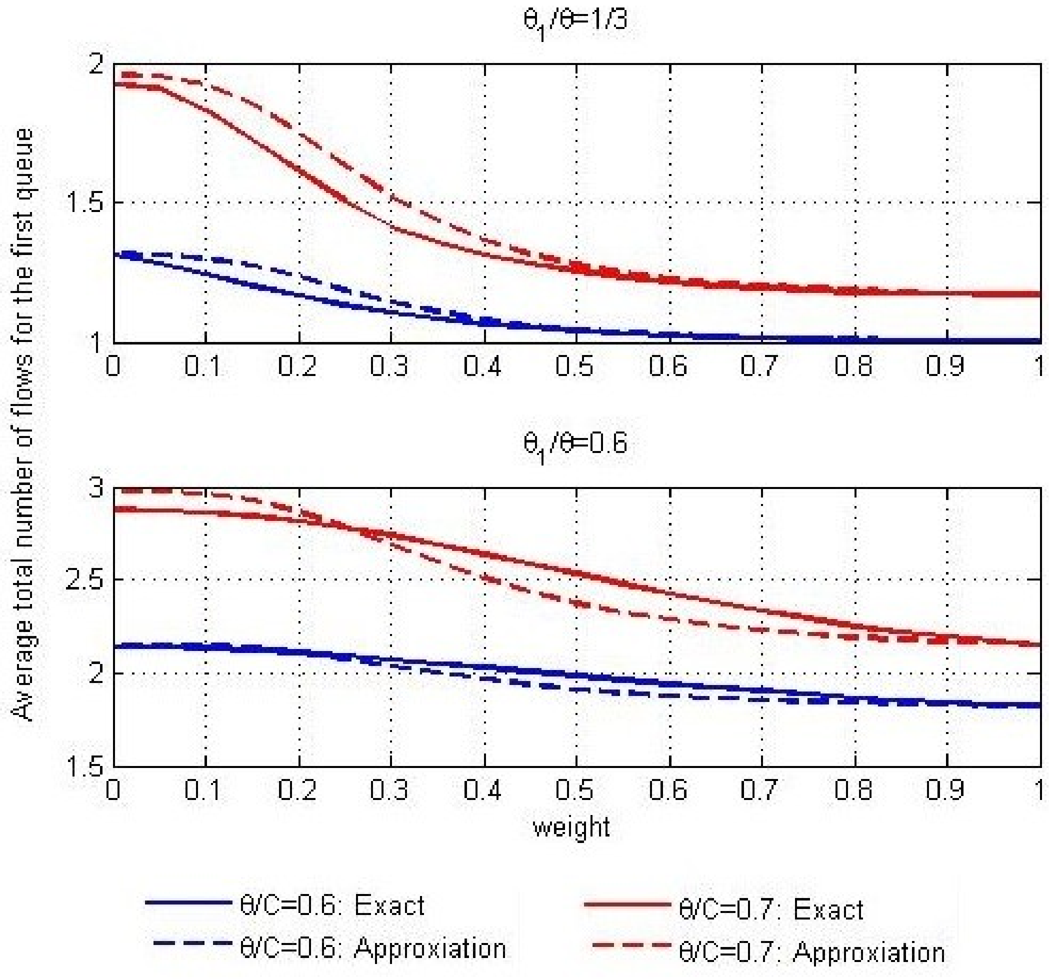
$C = 20$

$M = 3$

Three elastic flow classes

$d = 4$

$$v_2 = 3v_3 = \frac{3}{4}(1 - v_1)$$



Comparison between the analytical and the exact result of the average number of flows for the first queue in function of the weight assigned to it

$$C = 100$$

LLQ queue

$$M = 3\ (v_1 = 0{,}85, v_2 = 0{,}1, v_2 = 0{,}05)$$

Three TCP flow classes(50% *of the capacity*)

Two UDP flow classes(10 → 30% *of the capacity*)

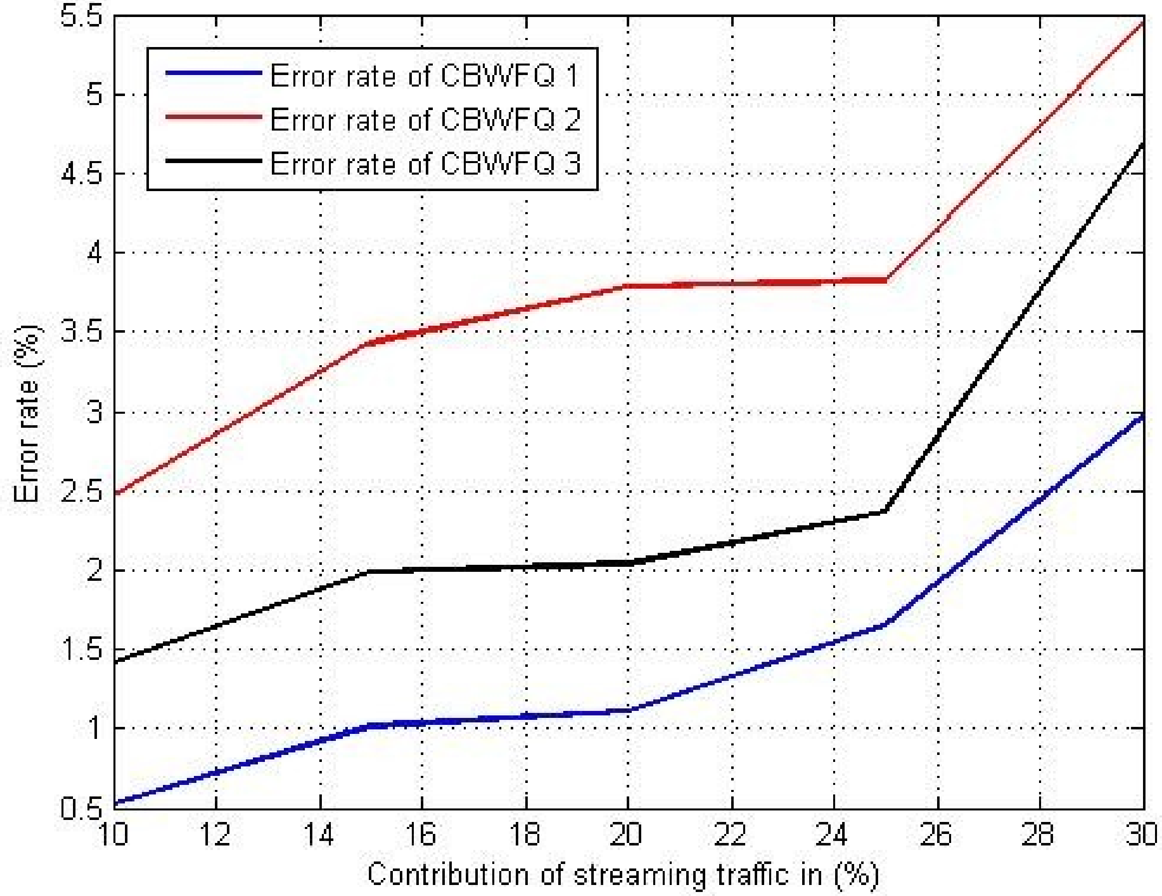
$$d = 4$$

$$d_1^{(s)} = 10, d_2^{(s)} = 20, d_3^{(s)} = 5$$

$$\theta_1^{(e)} = \theta_2^{(e)} = \theta_3^{(e)}$$

$$\rho_1^{(s)} = \rho_2^{(s)}$$

$$\frac{\lambda_j^{(s)}}{\lambda_i^{(e)}} = 0{,}1 \quad \forall i \in E, \forall j \in S$$



Evaluation of the error rate between the approximate and simulation result for the three CBWFQ queues

- We proposed a fluid model to evaluate the average end-to-end throughput of elastic traffic under multi-queuing system using a quasi-stationary approximation.

- The main contribution of this paper is the new methodology presented to treat the LLQ system, and more precisely the new approach given to study the CBWFQ system dedicated for the elastic traffic.

- The approximation given for the CBWFQ system express the average total number of flows for a queue independently to the weights assigned to the other queues. Although that this approximation gives a good results, further work is needed to improve the accuracy of the proposed model.

Thanks

For Your Attention