



**PhD in Information Technology and Electrical Engineering**

**Università degli Studi di Napoli Federico II**

**PhD Student: Pasquale Imputato**

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**XXXI Cycle**

**Training and Research Activities Report – Third Year**

**Tutor: Stefano Avallone**



UNIVERSITÀ DEGLI STUDI DI NAPOLI  
**FEDERICO II**

# Training and Research Activities Report – Third Year

PhD in Information Technology and Electrical Engineering – XXXI Cycle

Pasquale Imputato

## 1. Information

- a. Pasquale Imputato, MS in Computer Engineering – University of Naples “Federico II”
- b. XXXI Cycle - ITEE - University of Naples “Federico II”
- c. Fellowship type: University of Naples “Federico II”
- d. Tutor: Stefano Avallone

## 2. Study and Training activities

- a. Courses
- b. Seminars
- c. External courses

Student: Pasquale Imputato  
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Tutor: Stefano Avallone  
[stefano.avallone@unina.it](mailto:stefano.avallone@unina.it)

Cycle XXXI

	Credits year 1								Credits year 2								Credits year 3								Total	Check
	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4	5	6	Summary		
Modules	20			3	5	6	8	22	10	6			4			10	0							0	32	30-70
Seminars	5	1.6	1	1	1.6		3	8.2	5	3.5	0.3	1.5			0.3	5.6	0							0	13.8	10-30
Research	35	4	7	7	4	4	4	30	45	3	9	5	10	10	9	46	60	9	10	10	10	10	10	59	135	80-140
	60	5.6	8	11	10.6	10	15	60.2	60	12.5	9.3	10.5	10	10	9.3	61.6	60	9	10	10	10	10	10	59	180.8	180

## 3. Research activity

- a. Title: Network traffic control design and evaluation
- b. Study: traffic control, queueing discipline, bufferbloat, active queue management, queue sizing, dynamic queue sizing, network simulation, network emulation, performance evaluation, Linux networking stack, ns-3, 802.11, LTE
- c. Research description:

Recently, the term bufferbloat has been coined to indicate the uncontrolled growth of the network queueing time. A number of network traffic control strategies have been proposed to control network queueing delay. Active Queue Management (AQM) algorithms such as RED, CoDel and PIE have been proposed to drop packets before the network queues become full and to notify upper layers, e.g., transport protocols, about possible congestion status. Innovative packet schedulers such as FQ-CoDel, have been introduced to prioritize flows which do not build queues. Strategies to reduce device buffering, e.g., BQL, have been proposed to increase the effectiveness of packet schedulers.

Network experimentation through simulators such as ns-3, one of the most used network simulators, allows the study of bufferbloat and to evaluate solutions in a controlled environment. In this work, we aligned the ns-3 queueing system to the Linux one, one of the most used networking stacks. We introduced in ns-3 a traffic control module modelled after the Linux one. Our design allowed the introduction in ns-3 of schedulers such as FQ-CoDel and of algorithms to dynamically size the buffers such as BQL. Also, we devised a new emulation methodology to overcome some limitations and increase the emulation fidelity. Then, by using the new emulation methodology, we validated the traffic control module with its AQM algorithms (RED, CoDel, FQ-CoDel and PIE). Our experiments prove the high fidelity of network emulation and the high accuracy of the traffic control module and AQM algorithms.

Then, we show two case studies of design and evaluation of traffic control strategies by using ns-3. Firstly, we designed and evaluated a traffic control layer for the backlog management in 3GPP stacks. The approach improves significantly the flows performance in LTE networks. Secondly, we highlighted possible design flaws in rate based AQM algorithms and proposed an alternative flow control approach. The approach allows the improvement of the effectiveness of AQM algorithms.

Our work will allow researchers to design and evaluate in a more accurate manner traffic control strategies through ns-3 based simulation and emulation and to evaluate the accuracy of other modules implemented in ns-3.

#### d. Collaborations

During the third year, we collaborated with Centre Tecnològic de Telecomunicacions de Catalunya (CTTC) on advanced techniques of traffic-control in 3GPP stacks.

#### 4. Products

##### a. Publications

- i. P. Imputato, N.Patriciello, S. Avallone, J. Manges-Bafalluy, Smart backlog management to fight bufferbloat in 3GPP stacks, accepted for publication in Consumer Communications & Networking Conference (CCNC), 2019
- ii. P. Imputato, S. Avallone, Enhancing the fidelity of network emulation through direct access to device buffers, under review in Journal of Networks and Computer Applications (JNCA)
- iii. P. Imputato, S. Avallone, Avoiding active queue management design flaws: the PIE case, under preparation

##### a. Details

##### b. Presentations made

#### 5. Activity abroad

Visitor at CTTC in the Communication Networks Division

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## 6. Tutorship

Exam assistant to the BS course of Calcolatori Elettronici I and MS course of Protocolli per reti mobili. Seminar on bufferbloat to the MS course of Protocolli per reti mobili.