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In memory of Jean Van Bladel

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Abstract

The scientific career of Jean Van Bladel is briefly reviewed followed by an overview of recent research results obtained in the university department he founded 1964.

1 Introduction

When in 1969 I started as a PhD student of Professor Jean Van Bladel, I could not imagine that this would turn out to be a defining moment in my professional career. Having worked closely with Jean Van Bladel at the university and in the framework of URSI, and eventually succeeding him as head of department and as Secretary General of URSI; for me Jean was a teacher and a mentor who I admired very much. He was in the true, profound sense of the word a gentleman, a man of integrity, a man of culture, gentle and trustworthy, a man for whom duty and honor were all important.

In this paper the scientific career of Jean Van Bladel will be summarized, followed by some reflections on his service to URSI and finally as a tribute to him the highlights of recent research results obtained in the Ghent university department he founded in 1964, will be reviewed.

2 Scientific career of Jean Van Bladel

Since it is completely impossible to enumerate within the scope of this paper all the scientific achievements and awards of Jean Van Bladel, only the main points will be highlighted.

After working as an associate professor and full professor at Washington University, St. Louis and the University of Wisconsin, Madison in the USA, Jean Van Bladel returned to Belgium to found, as a full professor, the laboratory which later would be renamed as Dept. of Information Technology. Until his retirement in 1987 he was the driving force behind the growth and the scientific successes of this department.

Witness to the vast and outstanding contributions of Jean Van Bladel to science in general and to electromagnetic theory and applications in particular, are his books [1] – [4] and numerous papers in scientific journals. Over a long and distinguished career, which lasted for over 60 years, he has exhibited a rare depth of understanding and originality and he, therefore, commands the respect of everyone in the electromagnetics community.

Over his distinguished scientific career Jean Van Bladel received many prestigious awards such as Heinrich Hertz Medal and the Antennas and Propagation Society's 1997 Distinguished Achievement Award from the IEEE, an Honorary Doctor's Degree from the University of Liège and both in 1978 and 1984 he was awarded the Francqui Chair at the Free University of Brussels. A complete list of his noteworthy professional service and other honors and awards is too lengthy to delineate here but let me simply say that it is truly impressive by all international standards.

3 URSI

In 1984 Jean Van Bladel was elected as Secretary General of URSI. For 10 years he devoted significant time and energy to the reorganization and revitalization of URSI. In recognition of his tireless efforts and tactful diplomacy in tricky international situations he was awarded the title of Honorary President of URSI.

My experience, first as assistant Secretary General to Jean Van Bladel and then as URSI Secretary General from 1994 to 2018, is that those years were indeed a challenging time for URSI. The world in general and technology in particular underwent rapid and fundamental changes. Mobile cellular communications became a dominant factor in telecommunications, the monopoly situation or government ownership of telecom operators was ended and industry instead of universities carried out most of the research in the field. In the same period URSI ceased to be the main truly international organization linking the countries in the political blocks of the post war world. On top of that in most countries the funding for the Academies was reduced, resulting in a reduction in the funding of URSI by those Academies. Adapting to all those changes turned out to be very difficult for an organization such as URSI, steeped in traditions going back to the beginning of the 20th century. Jean Van Bladel and later I endeavored to serve the subsequent URSI Boards to bring about the cost savings and adaptations to the new situations. Essential issues such as the focus on science and academia, the support for young scientists and keeping the national Member Committees as basic governing structure remained the constant factors.

4 Ghent University-Dept. of Information Technology

4.1 Overview

As a tribute to Jean Van Bladel, recent research results of the two main research groups of the department of Information Technology of the Ghent University will be presented in following sections. In the sixties Jean Van Bladel laid the foundations of this department and subsequently allowed me to grow and diversify it in new scientific directions, while Jean himself continued his research in the area of electromagnetic fields and waves. The new directions were directly aligned with emerging potential industrial applications. As a result, each of the research groups mentioned below gave rise to at least 6 spin off companies. Nevertheless, the scientific quality of the research is very high as attested by the publications in journals such as Nature. This type of research can only be obtained if the research groups have a sufficient critical mass. In a pure university environment this is difficult to achieve but the cooperation with the IMEC research center made this possible.

4.2 Photonics research group

The photonic research group dates back to when I started it in 1975. In the past 30 years it has been led very successfully by Prof. Roel Baets, who this year receives the John Tyndall award, one of the most prestigious awards in the area of photonics. The research of this group is focused on following domains:

- Photonic Integration: photonic systems on a chip
- On silicon: “Silicon Photonics”
- Enhanced with new materials such as III-V, ferro-electrics, graphene, …

Those technologies are applied in diverse areas such as:

- High-speed telecom and datacom
- Sensing for life sciences: visible and Mid-IR
- Optical information processing

Silicon photonics is the implementation of high density photonic integrated circuits by means of CMOS process technology in a CMOS fab, enabling complex optical functionality on a compact chip at low cost. This research is made possible by the close cooperation of the group with the research institute IMEC, one of the foremost CMOS research centers in Europe. Today the main application of silicon photonics is in the field of high bitrate transceivers for communication networks and data centers. Recently a Datacenter Optical Interconnects chip was demonstrated with a 53 Gbaud PAM4 transmitter (hence 106 Gb/s) based on the combination of a silicon photonics chip and a 55nm BiCMOS driver and optimized for low power consumption [5]. This is a typical result of the intensive collaboration with the high-speed electronics team of IDLab, the research group discussed in next section.

The integration of III-V devices (in particular lasers) on a silicon photonics platform is a long-sought goal. The group now has a strong focus on a new technology, called micro-transfer-printing, which holds the promise of low cost and high-volume integration of III-V and silicon. Micro-transfer-printing combines advantages of flip-chip and die-to-wafer bonding. This capability is a unique asset of the photonics research group. The focus is to transition this technology to an industry-grade TRL-level [6].

A recent result out of the micro-transfer-printing work, presented at ECOC2019, was a III-V-on-Si integrated widely tunable laser (covering the C-band) with a hybrid laser in which the gain is provided by the transfer printed InP gain block and the tuning (as well as the cavity mirrors) are provided by the silicon circuitry [7].

Quantum Integrated Photonics is another area in which the group is rapidly gearing up, simply because silicon photonics is widely expected to be a key technology in quantum technology and computing. A single photon emission (a key building block in any quantum system based on photons) was demonstrated in a silicon photonics circuit enriched with a 2D overlay material. The 2D material is a crystalline monolayer of WSe_2 [8].

The group has also built a strong track record in photonic implementations of neuromorphic computing. While this field is still very young it already raises a lot of industrial interest. Recently fiber distortion compensation was demonstrated showing a significant improvement of the bit error rate of a 32 Gb/s signal after passing it through a neuromorphic chip [9]. The group also investigates applications in biology and medicine (amongst others cell sorting).

While silicon photonics today is almost exclusively found in telecom/datacom products (a few million chips per year), we believe that sensing and medical applications hold the potential of leading to much larger markets (tens of millions of chips per year). The potential of silicon photonics in sensing is very diverse (LiDAR, gas sensing, fiber Bragg grating readout etc.). The use of silicon photonics in a medical device for early and non-invasive screening of cardiovascular diseases was demonstrated. The device measures the pulse wave velocity in the arteries, which is an important marker for arterial stiffness. A clinical feasibility study in Paris and Maastricht has provided promising results, but more work is needed to show that the signals lead to accurate data in a wide range of patients [10]. This is the focus of the future work in collaboration with medical device company Medtronic.

4.3 Internet Technology and Data Science Lab

This research group was formed around 1992 when I felt that next to photonic technology, software would become a dominant factor in telecommunications and indeed the whole of society. Since the beginning this research group was led very successfully by Prof. Piet Demeester initially focusing the research on communication networks and gradually expanding its research activities in the areas of fixed and wireless subsystems and networks, cloud computing, distributed intelligence and machine learning. In 2016 this research group was merged with two other research groups (DSLab – Ghent University and MOSAIC - University of Antwerp) to form the new research group IDLab (Internet Technology and Data Science Lab) that counts about 350 researchers and is focussing on the following key areas :

- Electromagnetics and high frequency design
- Wireless networking: high bitrate / density wireless systems
- Fixed networking
- Cloud and big data infrastructures
- AI for Robotics and IoT (Internet of Things)
- High performance computing for life sciences
- Machine learning, data mining and sensor fusion
- Semantic intelligence
- Multimedia processing

The group is also characterized by its extensive collaboration with industry. In view of the volume of research of this group, only the topics most relevant for the URSI community will be summarized below.

A recent contribution concerned how to make dynamic cloud configurations rhyme with deterministic performance in virtualized compute and network resources in cloud-based environments [11]. The service operator must somehow map the performance specification in the Service Level Agreement (SLA) to an adequate resource allocation in the virtualized infrastructure. In the paper the use of a Virtualized Network Function (VNF) profile to alleviate this process is proposed.

Another recent result describes improvements in a Farrow-structured variable fractional delay (FD) Lagrange filter for all-pass FD interpolation for wideband software-defined radio [12]. The main idea is to integrate the truncated sinc into the Farrow structure of a Lagrange filter, in order that a superior FD approximation in the least-square sense can be achieved.

The original area of interest of Jean Van Bladel is still being pursued with a recent design of highly efficient ultra-wideband antenna systems that yield high performance at low manufacturing cost as required for The Internet of Things applications. Therefore, a novel ultra-wideband circular air-filled substrate-integrated-waveguide (AFSIW) cavity-backed annular slot antenna is proposed that enables straightforward integration into general-purpose materials by means of standard manufacturing techniques. The cavity top plane, serving as antenna aperture, contains two concentric annular slots, both split into two by shorting tabs that create a virtual electric wall [13].

Another interesting result in the area of antennas is an advanced transmit remote opto-antenna unit that accomplishes impedance matching between a photodetector and a low-profile antenna in a specified frequency bandwidth, without requiring an area-consuming matching network. The photodetector is almost directly connected to the antenna, which is designed as a conjugate load, such that the extracted and radiated power are optimized. The required input impedance for the antenna is obtained by adopting a half-mode air-filled substrate-integrated-waveguide topology, which also exhibits excellent radiation efficiency. [14].

A new concept for wireless networking at fiber speed was described in [15]. To provide wireless networking at 100 Gb/s per square meter with latencies smaller than 10 microseconds, ultrasmall floor-integrated cells are proposed. Radio frequency (RF)-over fiber coherent communication and a dedicated 2-D passive optical network structure support the interconnection and selection of the cells and minimize the required transceiver electronics.

A combination of artificial intelligence techniques and wireless communication technology resulted in a Spectrum Prediction Collision Avoidance (SPCA) algorithm that can predict the behavior of other surrounding networks, by using supervised deep learning. It adapts its behavior to increase the overall throughput of both its own Multiple Frequencies Time Division Multiple Access network as well as that of the other surrounding networks [16].

LoRaWAN (Long Range Wide Area) has attracted much attention for the realization of many Internet of Things applications because it offers low-power, long-distance, and low-cost wireless communication. In a recent interesting contribution, a synchronization and scheduling mechanism for LoRaWAN networks consisting of class A devices was proposed. The mechanism runs on top of the LoRaWAN MAC layer [17].

In the area of IOT the research group also participates in several international testbeds for internet-of-things that allow an increase in speed of prototyping and real-life validation, both being very valuable for the development of new systems and services.

The research group has many cooperative projects with industry such as the “High Performance Computing for DNA sequencing” project with Intel and Janssen Pharmaceutica (part of Johnson & Johnson) to accurately detect low-occurrence single nucleotide and structural variance. In this project IDLab developed a scalable sequence processing pipeline using 15 nodes x 24 CPU cores, thereby obtaining a speedup of 192 times compared to single core sequential processing.

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