<u>The second category decided in the seventh edition of the awards</u>

The BBVA Foundation Frontiers of Knowledge Award goes to Leonard Kleinrock, who made the Internet possible by devising the most efficient way to share data and transmit information

- Kleinrock made a seminal contribution to the development of packet switching transmission, the cornerstone of the future Internet
- He believes the Internet will extend its reach and capabilities further still to become the "global nervous system of the world"

Madrid, January 13 2015.- The BBVA Foundation Frontiers of Knowledge Award in the Information and Communication Technologies category has been granted in this seventh edition to American engineer Leonard Kleinrock "for his seminal contributions to the theory and practical development of the Internet," in the words of the jury's citation.

Responsible for establishing the first remote connection between two computers, Kleinrock's theoretical and technological contribution is foundational, in the view of the prize jury. Without his development of queueing theory and data packet switching, there could have been no Internet as we know it today. His idea of breaking down messages and using all available channels to transmit the resulting data packets proved the most robust way to organize information traffic.

On October 29, 1969, as part of the ARPAnet project funded by the United States Department of Defense, the first ever host-to-host connection was made, laying the groundwork for the future Internet: two computers several kilometers apart, in UCLA and the Stanford Research Institute (SRI), connected by a 50 kb/s line that was then considered high-speed, prepared to transmit the word "login". At the first attempt, the SRI received only the "l" and "o" before the system crashed. But a short time later, the message came through and the first ARPAnet link was established. Kleinrock was in charge of the operation, chosen for the theoretical background he was able to provide.

His contributions rested on a central idea: the possibility to maximize resource sharing by the users of a communication network. Kleinrock saw that this was an indispensable pre-condition to get computer networking off the ground, and had in fact worked on the problem in the course of his doctoral studies.

The solution he turned to was a mathematical tool called queueing theory, which studies how to manage a network with optimal efficiency by juggling resources and users. Kleinrock was then able to develop this theory for the specific case of a data-sharing network. This work led him to packet switching technology, which, as the jury explains, is "one of the basic technologies behind the Internet."

Kleinrock (New York, 1934), Distinguished Professor of Computer Science at the University of California, Los Angeles (UCLA) declared himself "thrilled and honored" on being informed by phone of the award, which was a "wholly unexpected surprise." He continues supervising students and is currently engaged in a research project that looks precisely at "what it was about the environment of the 1960s and 1970s that allowed the creation of such wonderful innovations."

His passion for engineering was sparked at the age of 6, when he built a crystal radio following the plans found in the pages of a Superman comic. Two decades later, in the early 1960s, he was doing a doctorate in electrical engineering and computer science at Massachusetts Institute of Technology. A disciple of Claude Shannon (regarded as the founding father of information technology), he elected to chart his own course and grapple with the problem of "how to get computers to talk to each other."

"Of course it was something in the air, that had been there for some time – Kleinrock refers in passing to the work of Nikola Tesla at the start of the 20th century – but it was not the goal of many research teams." In his PhD thesis, in 1962, he defended the imperative of sharing network resources and developed his application of queueing theory.

He offers an example illustrating the importance of network efficiency: "In a phone conversation, the line is exclusively dedicated to both users, even when they're not speaking. I realized that a data network built in that way would be inefficient and prohibitively expensive." It would be like a freeway network, he adds, that could only be used by one vehicle at a time.

His development of queueing theory enabled network capacity to be shared through the application of packet switching: each message is broken down into small, equal-sized blocks and transmitted over the network by what we now call a router – the backbone of Internet, present in every connected home. The idea is for these small data packets to occupy all the free space within the connection so they arrive faster than a single large packet and without problems of congestion.

Another example drawn from daily life: a supermarket queue would operate more efficiently – in terms of each customer's waiting time – if those with the smallest baskets paid first. An analogy for how packet switching works is that each customer pays the same small number of items each time a checkout becomes free, reducing the average waiting time of all those in the queue.

At the time of that first ARPAnet connection, in 1969, Kleinrock had never seen his theories tested in practice, though a series of simulations had convinced him they would work. And the word "login" would prove him right.

Starting from Kleinrock's work, queueing theory has found application in countless domains, as the jury points out: "The development of queueing theory, that allowed the disruptive transition from circuit switching (as used in analog telephone networks) to packet switching, has great significance not only for the Internet but also for many other fields such as traffic control, logistics, manufacturing and transportation. In all these applications queueing theory leads to significant reduction of waiting times."

"The global nervous system of the world"

Even before the successful transmission of 1969, Kleinrock had outlined his vision of a "permanently available" future network, open to everyone and as "invisible" as electricity. Nowadays, he is convinced that the Internet's impact will run deeper still: he predicts an everyday environment "full of cameras, sensors and small wearable devices," that are continuously gathering and sending data on us all: "When I enter a room, the room will know it, and I'll be able to ask it where I left my book or keys," he predicts. "The Internet will become the global nervous system of the world."

Of course this technology will not be without its drawbacks in matters like security or privacy. "Unfortunately loss of privacy is a done thing, we give up our privacy the moment we open an email account or start carrying a cell phone."

Bio notes

Leonard Kleinrock studied at the Bronx High School of Science, a public center attended by Nobel Physics laureates Leon Cooper and Steven Weinberg, and Robert J. Lefkowitz, 2009 BBVA Foundation Frontiers of Knowledge laureate in Biomedicine and winner of the Nobel Prize in Chemistry in 2012.

Unable to afford university, he worked during the day as an electronics technician, then attended evening classes at the City College of New York where he completed a bachelor's degree in electrical engineering.

His excellent grades earned him a full graduate fellowship to pursue his studies at the Massachusetts Institute of Technology (MIT). When the time came to choose a subject for his PhD, while most of his colleagues were delving into information theory, he preferred to break new ground in the virtually unknown area of data networks.

In 1963, he joined the faculty at UCLA, where he continues today as Distinguished Professor of Computer Sciences.

Author of 18 patents, he has published over 250 papers and six books on a wide array of subjects, including packet switching networks, packet radio networks, local area networks, broadband networks, nomadic computing and peer-to-peer networks.

Dr. Kleinrock is a member of the National Academy of Engineering and the American Academy of Arts and Sciences, and a founding member of the Computer Science and Telecommunications Board of the National Research Council. It was under his leadership that the latter organization prepared the strategic document "Towards a National Research Network" that became a cornerstone of technology policy.

His multiple distinctions include the National Medal of Science, the highest honor for scientific merit, granted by the President of the United States.

About the BBVA Foundation Frontiers of Knowledge Awards

The BBVA Foundation promotes, funds and disseminates world-class scientific research and artistic creation, in the conviction that science, culture and knowledge in its broadest sense hold the key to a better future for people. The Foundation designs and implements its programs in partnership with leading scientific and cultural organizations in Spain and abroad, striving to identify and prioritize those projects with the power to move forward the frontiers of the known world.

The BBVA Foundation established its Frontiers of Knowledge Awards in 2008 to recognize the authors of outstanding contributions and radical advances in a broad range of scientific, technological and artistic areas congruent with the knowledge map of the late 20th and 21st centuries, and others that address central challenges, such as climate change and development cooperation, deserving of greater social visibility and recognition.

Their **eight categories** include classical areas like *Basic Sciences (Physics, Chemistry and Mathematics)* and *Biomedicine*, and other, more recent areas characteristic of our time, ranging from *Information and Communication Technologies, Ecology and Conservation Biology, Climate Change* and *Economics, Finance and Management* to *Development Cooperation* and the innovative realm of artistic creation that is *Contemporary Music*.

The **juries** in each category are made up of leading international experts in their respective fields, who arrive at their decisions in a wholly independent manner, applying internationally recognized metrics of excellence. The BBVA Foundation is aided in the organization of the awards by the **Spanish National Research Council (CSIC)**, the country's premier multidisciplinary research body. As well as designating each jury chair, the CSIC is responsible for appointing the Technical Evaluation Committees that undertake an initial assessment of candidates and draw up a reasoned shortlist for the consideration of the juries.

Committee members in the ICT category were Luis Hernández, senior scientist in the Institute of Physical and Information Technologies (CSIC); Juan José León, scientific researcher in the Institute of Fundamental Physics (CSIC); Manuel Lozano, CSIC Research Professor in the Institute of Microelectronics of Barcelona; Alberto Sanfeliu, university professor in the Institute of Robotics and Applied Informatics (CSIC-Universidad Politécnica de Cataluña); and Ángela María Ribeiro, senior scientist at the Center for Automation and Robotics (CSIC).

Information and Communication Technologies jury

The jury in this category was chaired by **George Gottlob**, Professor of Computer Science at the University of Oxford (United Kingdom), with **Ramón López de Mántaras**, Director of the Artificial Intelligence Research Institute of the Spanish National Research Council (CSIC) acting as secretary. Remaining members were **Rudolf Kruse,** Head of the Department of Knowledge Processing and Language Engineering at Otto von Guericke University Magdeburg (Germany), **Mateo Valero,** Director of the Barcelona Supercomputing Center (Spain) and **Joos Vandewalle,** emeritus professor in the Department of Electrical Engineering (ESAT) at KU Leuven (Belgium).

Previous laureates

The winner in the last edition was American **Marvin L. Minsky**, regarded as a founding father of the artificial intelligence field. Minsky is also the author of key theoretical and practical contributions in mathematics, cognitive science, robotics and philosophy. A co-founder of the prestigious Artificial Intelligence Laboratory at the Massachusetts Institute of Technology, he was also instrumental in establishing the MIT Media Lab.

Preceding him as laureate was **Lotfi Zadeh**, a professor in the Department of Electrical Engineering at the University of California, "for the invention and development of fuzzy logic." This "revolutionary" breakthrough has enabled machines to work with imprecise concepts, in the same way humans do, and thus secure more efficient results more aligned with reality.

The award in the fourth edition went to American electronic engineer **Carver Mead**, of California Institute of Technology, for being "the most influential thinker and pioneer" of the silicon age, and enabling "the development of the billion-transistor processors that drive the electronic devices – laptops, tablets, smartphones, DVD players – ubiquitous in our daily lives."

American mathematician **Donald E. Knuth** of Stanford University took the award in the third edition for "making computer programming into a science by introducing formal mathematical techniques for the rigorous analysis of algorithms." In the second edition, the award was granted to **Thomas Kailath of** Stanford University "for breaking through the barrier of chip miniaturization, enabling the production of increasingly small size chips, and inventing methods to pattern integrated circuits with components finer than the lightwaves used in their production." Finally, the inaugural award went to **Jacob Ziv** of Israel's Technion Institute for "his ground-breaking innovations in data compression."

UPCOMING AWARD ANNOUNCEMENTS

CATEGORY	DATE
Basic Sciences	January 20, 2015
Biomedicine	January 27, 2015
Ecology and Conservation Biology	February 3, 2015
Contemporary Music	February 10, 2015
Economics, Finance and Management	February 17, 2015
Development Cooperation	February 24, 2015

LAUREATE'S FIRST DECLARATIONS AND IMAGES

A video recording of the new laureate's first interview on receiving news of the award is available from the Atlas FTP with the following name and coordinates:

Server: **213.0.38.61**

Username: **AgenciaAtlas4**

Password: **premios**

The name of the video is:

"PREMIO FRONTERAS DEL CONOCIMIENTO CATEGORÍA TIC"

In the event of connection difficulties, please contact Alejandro Martín at ATLAS:

Mobile: +34 639 16 58 61

E-Mail: amartin@atlas-news.com