Inside TRACK with Amir Eliaz,

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Interview by JEAN-JACQUES DELISLE

"In five years, we'll create and discard more content in a day than we now create and save in one year."

JJD: What technology trend is having the biggest impact on the communications market today?

AE: Connectivity is still the name of the game. The development of very-low-power, energy-efficient wireless devices will enable another 10 to 100 billion devices to be connected to the Internet—including machine-to-machine (M2M) connections and the "Internet of Things" (IoT). All those devices connecting with the network will cause bottlenecks. We believe our WAve Modulation (WAM) helps here, as there will be a need for extremely high-speed wireless-backhaul links to get around right-of-way issues. Such connectivity also will be aided by the development of good, inexpensive infrastructure to connect homes and offices to the Internet backbone at speeds far exceeding what we see today. Solutions based on small cells will be used to improve access reach while solutions like WAM will help by taking advantage of the increased signal-to-noise ratio (SNR).

JJD: What are some of the big application-layer shifts driving new needs at layer 1?

AE: First, more processing is happening "in the cloud" (i.e., at some server farm [Amazon EC2, Google, etc.]). There is an increased need for high-speed and low-latency connections between fixed and mobile devices to the Internet backbone. We're relying on these new "cloud-based" services all the time—for navigation, processing data from sensors on our body (for health and fitness monitoring), and posting, consuming, and searching for content. Many more devices need a connection to the Internet backbone and services that ride on top of them. Whether they are smart watches, wristbands, or sensors that will measure our pulse or footsteps, their data must be aggregated somewhere else. And don't forget video, which is the new still photo. We will be capturing a lot more visual data-—much of which is of limited temporal value. In five years, we'll create and discard more content in a day than we now create and save in one year. Much of that content will never be seen by a human being, but will automatically be processed and filtered. All this means that we'll need more bandwidth.

JJD: From a communication designer's viewpoint, what is the biggest challenge in meeting design demands?

AE: First, we need to ensure that the high-speed pipes we're building into mobile devices don't drain the batteries or render the device too hot to hold. These are big problems. Wireless interfaces now are a top consumer of power (and energy per processed bit) in most mobile devices. Second, we need to ensure sufficient access capacity to users in dense urban areas. We also need to provide sufficient backhaul capacity to the core network. Meanwhile, costs need to keep dropping.

JJD: From a communications technology

standpoint, what must be done to meet the demands for "big data"?

AE: Excellent question. We need both very big backhaul and access pipes for mobile devices to provide the high-speed burst capabilities for opportunistically generated and consumed video content. They also will support "real-time" cloud-based services using input from these devices. We don't have a lot more "quality spectrum," so we need solutions that maximize spectrum utilization.

JJD: What major challenges do you face when designing communication systems for millimeter-wave applications?

AE: There are a number of them. Antenna and feed design is a massive challenge in some devices. To achieve the highest data rates, large antenna-array gains would be required to meet the link-budget constraints for reasonable distances (more than a couple of meters). These channels change very, very rapidly. So, sophisticated beamforming algorithms are required. In addition, a lot of processing power is needed to update the arrays. In mobile-backhaul and small-cell applications, the radio is very nonlinear. These nonlinearities cause the radio to suffer from amplifier compression and frequency-source phase noise, which limit spectral efficiency. Current systems are operating at low spectral efficiency because of the amount of available spectrum, which is not ideal. In the future, however, high-order modulation should be used as spectrum is less available and nonlinearity becomes a critical issue.

JD: What are the requirements for enabling higher-constellation quadrature-amplitude-modulation (QAM) systems?

AE: For backhaul systems, the challenges are primarily nonlinearities in the channel—both phase noise at the transmitter/ receiver, power-amplifier (PA) compressive nonlinearities, and phase noise. These limit the maximum spectral efficiency for QAM today. For mobile wireless systems, we see the same challenges—plus substantial co-channel interference.

JJD: How are communications engineers handling the new requirements of LTE-A with multiple-input multiple-output (MIMO) and carrier aggregation?

AE: MIMO suffers the problem of increased complexity at the receiver—particularly in frequency reuse 1 systems, in which there is substantial co-channel interference at the cell boundaries (the majority of the area). Apparently, carrier aggregation provides higher per-user throughput, but it requires clever scheduling to avoid higher latency for some users. It would be beneficial to also increase spectral efficiency for a single spatial channel.

JJD: Where in the communications-technology industry do you see the largest need for investment?

AE: There is a need for more capacity per user (and for more users)—particularly in urban areas. That will mean more and even smaller cells, and the corresponding problem of connecting those cells to the rest of the network (right-of-way issues). In addition, we'll need some additional improvements in access technology. Lower-power wireless transceivers also will be required to enable access all the time, anywhere. As spectrum becomes more and more congested, practical solutions must be proposed for using higher-channel frequencies that suffer from nonlinearities as well as limited propagation characteristics.

JJD: In your opinion, what technology or software tools are most valuable to a communication engineer?

AE: It depends. MATLAB is used a lot. But so are Octave and Python. Developers of MAC protocols use NS or Opnet. Everyone writes a lot of C and C++, but there many tools are used for development. At some point, a real-time emulator is useful, and then it is helpful to build a prototype on a field-programmable gate array (FPGA).

JJD: What are companies looking for in a communications engineer?

AE: Most importantly, excellent fundamentals in mathematics, statistics, information theory, signal processing, and economics. Yes, economics. It is helpful to have some practical experience implementing hardware—usually by writing Verilog and/or VHDL. Good coding skills in C/C++ and familiarity with rapid prototyping in MATLAB are helpful. Python is invaluable for data analysis and control of lab equipment. This person must also be very creative in defining the communication problem and seeking the best practical solutions.

JJD: How do communications engineers keep up to date on the latest in the field?

AE: Read math books—seriously. Keep up with some of the latest published work in a couple of key subfields. These days, there is a lot of excellent work in codes and the application of information theoretic concepts to machine learning. All of these disciplines are interrelated. The dimensions in any communications scheme are continuously increasing—for example, from single-carrier to multicarrier (OFDM), from single-input single-output (SISO) to MIMO and from QAM to WAM. Such innovations should be backed by a mathematical background and fundamental understanding of communication theory.

JJD: In what ways could the communications industry attract more young engineers to the field?

AE: The key is to show everyone the massive opportunities that remain. Much of the news of late has focused on how the communications semiconductor business is moribund. The reality is that much of the failure is the result of trying the same thing too many times. The communications business is much more mature and efficient today; it is harder to make a big splash. There are plenty of opportunities, but understanding the remaining market opportunities is key. The technologies that are considered for next-generation communications involve sophisticated and challenging methods, such as carrier aggregation (in LTE-A, for example), which may attract young engineers seeking real challenges.