Accelerating Wireless Device Development with Network Emulation

by Rajive Bagrodia, Scalable Network Technologies

As global demand for high-speed mobile IP communications grows in both commercial and military sectors, multiple technology platforms are competing to become the 'standard' for fast, scalable, and interoperable mobile communications.

The economic realities of upgrading existing wireless communications infrastructures require technologies that can be layered on top of existing networks to add capacity and increase data rates. In the commercial sector, 2G and 3G networks are becoming capacity constrained as mobile broadband use increases.[1] Two new standards are competing to meet this demand. Mobile WiMAX, backed by industry heavyweights like Intel, Google, Sprint, and Time Warner, is in early stages of deployment, initially achieving a 3X capacity improvement over existing technologies, with another 50% boost expected from the adoption of MIMO enabled systems. The 3GPP Long Term Evolution (LTE) standard, backed by Nokia Siemens Networks and an international consortium of standards bodies, it at least two years away from deployment, but promises substantially higher data rates and capacities than WiMAX.[2] Both of these technologies are being designed to overlay onto existing 2G/3G network infrastructures, creating demand for a new array of multimode devices such as mobile phones, notebook computers, PDAs, MP3 players, and mobile TVs.

In the military sector, the mobile ad hoc network (MANET) is becoming the tactical communications network of the future. MANETs consist of wireless mobile devices or "nodes" that can freely and dynamically self-organize into temporary networks, allowing people and devices to interconnect in areas with no communications infrastructure, such as disaster recovery environments or battlefields. Because MANETs are set up 'on the fly' without infrastructure components such as access points or base stations, every connected mobile device acts as both host and router. As devices move over terrain and through varying weather and atmospheric conditions, they may connect and disconnect repeatedly from the other devices. As IP technology continues to mature, developers seek to incorporate technology advances into their devices to overcome the environmental effects on reachability and latency from node to node. Commercial applications of MANET are now being explored, enabled by technologies such as Bluetooth, WiFi, and HyperLAN.

Each wireless networking standard offers unique advantages and deployment challenges. But the fact that all are fundamentally IP-based technologies offers unprecedented opportunity for device developers to create products that seamlessly interoperate among these layered network standards.

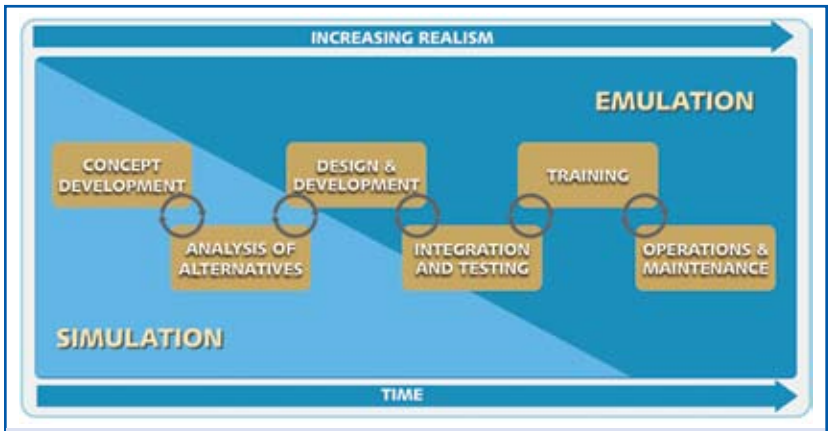

Figure 1: How simulation and emulation fit into the product development cycle

Common Challenges in Network Design and Deployment

While commercial and military communications applications have substantially different functionality and quality of service requirements, there are a common set of challenges in designing and deploying wireless networks to satisfy those requirements. Primary among these challenges is developing new technologies that raise the bar in terms of performance while supporting legacy systems. Validating designs from the component level to the system-of-systems level is necessary at numerous stages in the design process.

Comprehensive testing of actual network prototypes is a costly but necessary practice prior to deployment. Hardware, software, and links must be tested, validated and verified. Currently, the problem with testing is that the two methods commonly employed – simulation and physical testbeds – are only useful at the very beginning or very end stages of development. Early stage simulations are not always accurate, whereas late-stage testbeds are very expensive. There is a real need for better, lower-cost testing in the middle and later stages of product development.

Technology Breakthrough: Software Virtual Networks

Our company has introduced a breakthrough technology that accelerates the design and development cycle for mobile network devices, and also improves device performance by pinpointing risk factors that can cause communication breakdowns in operation.

"Software virtual networks" (SVNs) can now be built that enable engineers to evaluate new component designs and technologies faster and at much lower cost than has been possible until now. SNT's EXata emulation environment is built on a technology called true emulation to create exact digital or "virtual" duplicates of live, complex physical networks. Any hardware, software, or human user connected to this emulated network is not able to tell the difference between a real network component and its emulated replacement.

Network emulation blends the flexibility and low cost of simulation with the highly accurate, highly detailed results of a physical testbed. Emulation is valuable throughout the development life-cycle and can be employed at increasing levels of detail and realism as each project demands (see **Figure 1**).

Simulation vs. Emulation

Today, device testing is conducted with a combination of simulation technology and physical "testbeds," scaled-down versions of fully-deployed networks built with prototypes of the new devices being evaluated.

Simulation has become highly sophisticated over the last twenty years, and is best suited for evaluating solution concepts and initial designs in the early stages of the development cycle. Depending on the complexity of the network and the need for real-world fidelity, large-scale simulations and/or testbeds are used to evaluate designs prior to deployment.

Network simulation models very complex networks; as a result, nearly all simulation solutions abstract or simplify the network model. Calculation times can be prohibitively long even on fast computing platforms, taking up to two weeks to generate simulation results for a one-hour experiment. As

a result, most engineers view simulation as impractical for testing extremely complex systems because it can mask the very performance enhancements they are developing.

There are also fidelity challenges in building efficient radio, channel and mobility models. Network models that fail to take into consideration details like radio frequency propagation, channel interference, and precise node location may render experimental results meaningless.

EXata is an emulator that breaks new ground in speed and fidelity compared to competitive systems. The underlying computer code, known as the kernel, is built with patent-pending computationally efficient code that dramatically increases speed and accuracy on any computing platform (see Figure 2). EXata is the only emulation system that can use advanced parallel processing to digitally represent every layer in the wireless communications protocol "stack" (See Figure 3).

Because hardware, software, or human users connected to an EXata SVN can't tell the difference between a real network component and its emulated replacement, engineers can develop "virtual prototypes" and integrate them into the SVNs, which in turn can be interoperated with existing deployed networks. EXata SVNs also produce greater predictability of actual performance. Many more potential solutions can be tested and evaluated in a given time period, allowing engineers to solve more problems with fewer technical compromises.

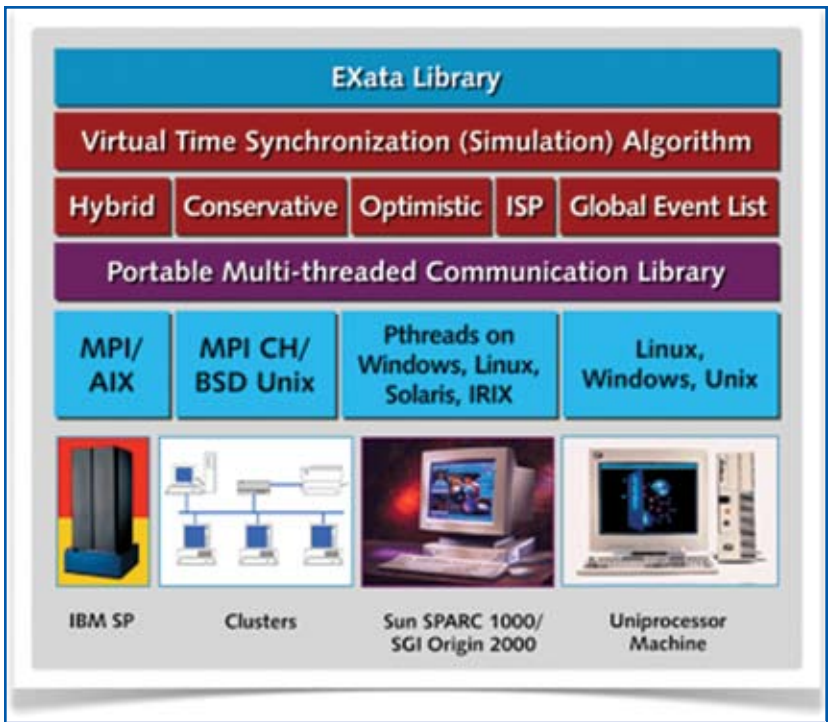

Figure 2: EXata Parallel Processing Architecture

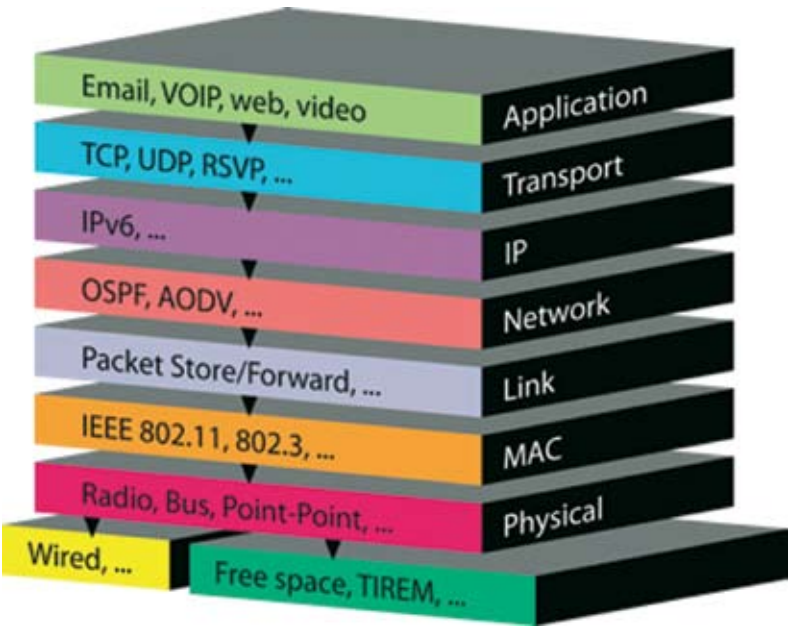

Figure 3: How EXata mimics the structure of physical networks

Design Application: L-3 Communications

SNT emulation technology is being used by L-3 Communications to develop the MR-TCDL, a Wireless, IP-based, Mobile Ad Hoc Networking System that provides high bandwidth capacity over very long ranges. SNT's first-generation emulation, part of the QualNet Developer environment, is used to validate MR-TCDL applications and hardware and refine system designs.

Prior to test flights featuring real aircraft, L-3 connects real WMR/MR-TCDL prototypes to an emulated fleet of aircraft in QualNet. The pre-test-flight validation process, which takes place early in the system design and development phases, is intended to reduce the risk of system or network failure during system testing and actual flight test acceptance phases.

With real hardware and actual algorithms integrated into the emulation, protocol service verification takes place throughout various stages of product development, not just at the final step. Simulation and emulation through SNT's QualNet and EXata provide critical understanding for refining the performance of IPCM, network protocols and other network services.

Once the test flights are underway, emulation is used to provide support with real-time 3D visualization of link status and telemetry data. By providing operational-level validation of networking software and hardware, emulation helps L-3 build a better solution faster and more inexpensively.

Better Designs, Lower Development Cost

Network emulation with EXata, as a replacement for costly testbeds, provides wireless device developers with two substantial benefits. First, emulation enables engineers to test and evaluate design prototypes much earlier in the design process, at a fraction of the cost of physical testbeds. Emulation reduces cost by minimizing prototype iterations through the development cycle. It also eliminates the need to acquire large physical spaces within which to construct testbeds; you can't test routing protocols or connectivity issues if all the radios are in the same room.

Second, EXata produces better predictability of actual performance because engineers can test solutions against all potential environmental effects. As a result, many more potential solutions can be evaluated and more problems can be solved with fewer technical compromises.

Summary

Software virtual networks are changing the way that wireless network devices are tested and evaluated. Between early stage abstracted simulations and late stage prototype test beds, emulation plays an important role in evaluating product designs. From the component level to the system-of-systems level, emulation enables evaluation in a real system context, greatly reducing the cost and time of testing and validation throughout the design cycle.

Not all network simulators are capable of true emulation. To be a true replacement for a network, an emulation must support real-time speed, full packet fidelity, and provide transparency. EXata supports true network emulation with parallel execution and highest fidelity models and the scalability and interactivity required to test and evaluate the most advanced new mobile communications devices.

Notes

1. "Deployment of Mobile WiMAX Networks by Operators with Existing 2G & 3G Networks," WiMAX Forum White Paper,

February 2008.
2. Morisy, Michael, "As Sprint bets big on WiMax over LTE, timing may be everything," SearchTelecom.com, May 8, 2008.
3. Brown, Adama D., "3GPP Long Term Evolution has successful field trials," Brighthand.com, January 10, 2008.