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Enable Interoperability to Unlock Agility

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Think of the last time you bought a new electronic communications device, expecting it would save you time and make life so much more pleasant. Perhaps it was a new Internet-connected television or smart-lighting system. Maybe you remember the thrills of trying to connect your phone to a new car, or a new phone to an old car. Was it easy? Or did you spend hours failing to make it work with all your other time-saving, life-fulfilling devices?

Isn't everything interoperable now?

We all recognize the frustration of interoperability problems. We quickly forget when things work as they should. Thankfully, we do have to think back to find the worst cases of poor interoperability, like before global mobile roaming or before the widespread adoption of short-range wireless connectivity technologies. Manufacturers are now taking the user experience more seriously and we find it easier to integrate our collection of devices into our networks and our lives.

Interoperability, however, doesn't come free. There are good business reasons for taking interoperability seriously. Lack of interoperability can be expensive. In an industrial context, interoperability problems can mean lost business: consider halted production lines or the collapse of telecom networks, for example. At the consumer level, brand reputation and brand equity can be negatively affected. The inverse is also true: some brands stake their reputation on interoperability and offer a complete ecosystem of devices and software all designed to work together. They can charge premium pricing because consumers place a value on things just working as they should.

Some are tempted to treat interoperability as an additional feature, something to be sorted out at the end of product development. But true interoperability is designed in from the beginning and is easier and cheaper to achieve this way. Systems should be designed to use standardized, secure interfaces and connections. These standards must be designed to enable interoperability. In product development and implementation, the standards used must be followed, without shortcuts, deviations or second-guessing the standard.

Achieving interoperability is one thing. Maintaining it is quite another. The environment for which a product is designed may evolve over time, such as with the introduction of new technologies in our networks. In a world defined by software, there will be a need to not only provide updates to fix errors and to enhance security, but also to maintain interoperability. Standards and technologies should not be used outside the context or purpose for which they were developed. They might work, but for how long?

Testing, testing, testing

One of the most important keys to enabling interoperability is testing. Multiple levels of testing are required, at multiple stages in the development cycle. Let's set aside the testing steps that should be part of any product development cycle: software unit tests, functional testing, performance, safety, usability and quality testing in general. Instead, we will look at testing focused on interoperability.

Testing can never be a substitute for designing for interoperability—they go together. Having designed for interoperability, and having chosen to follow communication standards that enable interoperability, it is essential to verify that a product conforms to those standards. Failure to follow the standard may result in interoperability issues. Pay particular attention to "failure states" or exception handling; steady state operation may be interoperable but what happens when something unexpected occurs? If the standard specifies a particular behavior, follow it. Often standards bodies will publish standardized tests used to verify compliance with a standard. Where they exist, use them.

Interoperability testing is an equally important second step. Where conformance testing will test for compliance to a specific communication standard or technology, interoperability testing takes an end-to-end view of the complete system. Specific components or technologies may work well in isolation but, when combined to interactwith other technologies in the one system, may trigger interoperability problems. In many cases, interoperability testing takes place among or against systems from other manufacturers. This provides valuable feedback to each participating manufacturer. It is also a powerful demonstration of multi-vendor interoperability, sending a strong message to the market.

There is a potential paradox, wherein a product conformant to a standard might not be interoperable, or interoperable products might not be conformant to the standard. Both cases signal problems. A technology standard should be designed to enable interoperability, covering

all behavior possible including error cases. And while two non-conformant products might interoperate, will they work with a third product, this time conformant?

Standards for interoperability

A thread is emerging here—that of communication standards, which themselves enable interoperability. How do standards bodies ensure that their standards are fit for purpose? In the case of ETSI and 3GPP™, we take similar pragmatic steps to those taken by industry. We design our standards for interoperability. We encourage conformance to standards by providing standardized conformance test specifications. We organize interoperability events for the industry. We have a standards committee dedicated to developing methods for testing and specification, together with a support team in our Secretariat, in our Centre for Testing and Interoperability.

Designing a standard for interoperability starts with ensuring the standard is of the highest quality. It must be technically accurate, covering all possible types of behavior, expected and unexpected. Where relevant it should make use of formal methods and code to make it easier to implement. The language used must be clear and unambiguous, to reduce the risk of misinterpretation. Options or alternatives offered in the standard must not result in interoperability issues.

Once a standard is developed, it must be tested. At ETSI, we use interoperability events to help us validate or verify our standardized technologies. We organize numerous interoperability events each year under the Plugtests brand, with cosponsorship from the European Union and EFTA. Vendors like to participate because they receive early feedback on their implementation or prototype. From a marketing perspective, interoperability events signal that a standardized technology is ready and has vendor support. However, the underlying purpose for a standards body like ETSI is to verify that there is a common understanding of the standard and that the standard does enable interoperability. These events are also an excellent opportunity to receive feedback for later improvements to the standard.

Conformance testing has been mentioned above; it is just as essential as interoperability testing. ETSI will often develop a set of standardized tests, for instance a test specification that is itself a standard, to accompany our technology standards. We have developed methodologies and best practices for test specification development, including a dedicated high-level coding language in which to describe the tests: TTCN-3. TTCN-3 has seen widespread adoption in the telecommunications industry with extensive tool support available, whether proprietary tools or in open source.

Voluntary certification programs, based on standardized test specifications, are a further step to encourage and promote interoperability. Coupled with a recognized brand and logo, a certification program based on real testing results will build consumer or industry confidence in a technology.

Interoperable mobile devices

Current practice in the mobile industry adopts all the techniques described above. A specific emphasis is placed on conformance testing although, where relevant, interoperability test specifications are developed or interoperability events are organized, often focused on specific use cases or scenarios such as mobile IoT, VoLTE, Cellular V2X or emergency calling.

3GPP, the global mobile standardization project producing the standards for 3G UMTS, 4G LTE and now 5G, develops and maintains an extensive set of conformance testing standards for the radio or user-network interface, to accompany each release of the base standards for mobile devices. These are managed in a dedicated working group made up of volunteer participants from 3GPP member companies. In addition, a team of experts is contracted to produce test specifications in TTCN-3 code. This TTCN-3 code is taken by test tool vendors, compiled on their test tools, and distributed to their customers. In this way, each successive release of 3GPP specifications has a specific set of test specifications, which are maintained and updated as the base specifications evolve. The use of TTCN-3 enables rapid updating of test tools, ensuring that all parties are using the latest, most up-to-date test specifications.

Working closely with 3GPP are a group of industry certification bodies such as the GCF™ or the CTIA™ PTCRB™ certification program, which provides device certification based on the successful execution of these standardized tests. While there is no legal obligation for a vendor to have a certificate from one of these bodies before placing a mobile device on the market, there is a general industry recognition of the value that certification brings. In many regions, network operators have influence over which devices are used on their networks, through the provision of device subsidies or reselling devices through their retail shops. In the highly competitive mobile device market, consumers expect perfect interoperability with the mobile network. No manufacturer can afford to launch a product that does not provide this.

Future complexity

This is simply a snapshot of how interoperability is enabled in one context. The process is repeated for each connectivity technology, whether using radio or not. Similar processes take place in the core networks.

Because many devices contain numerous connectivity technologies, interworking and coexistence as part of a single system become important. The pace of technological change adds to the complexity, where backwards compatibility and obsolescence need to be managed.

Consider the case of one of the fastest-growing segments for mobile and wireless technologies: the automotive sector. A modern car may have multiple radio and connectivity technologies on board. Some are obvious: FM, AM and satellite radio, GPS navigation, Bluetooth, USB, and wireless key fobs. Some are less so: automotive radar for adaptive cruise control and emergency

braking, NFC for quick pairing of mobile devices, wireless charging, tire pressure monitors, garage openers, wireless on-board diagnostics ports, and so on. Then drivers add their own mobile devices to the mix.

Now consider the lifecycle of a vehicle model: two to three years of design, over eight years of production and sales, with most vehicles lasting at least 10 years on the road, some even 20 years. Who can guess what technologies today's vehicles will need to connect with 20 years from now?

Software, especially software-defined radio, may provide us with the means to reuse existing hardware for new or upgraded radio systems. Artificial intelligence may also be of use. Studies are ongoing into using AI techniques to optimize testing, helping to focus on the areas or topics most at-risk of provoking interoperability problems. At the same time, AI-based communication technologies are under development. Testing these self-learning, self-organizing systems requires a whole new chapter in the book on enabling interoperability—and it's still being written.