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Essentials of Bringing a Bluetooth® Product to Market

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Topics Covered

- Quick introduction to Bluetooth.
- Deciding if a product should include Bluetooth support.
- The role of profiles.
- Creating your own stack versus licensing one.
- Should you use Bluetooth modules or buy chips?
- Selecting a chipmaker.

Topics Covered

- Bluetooth challenges for the product team.
- Partitioning the product (in terms of system design).
- What development tools are needed and how to use them effectively.
- Preparing for qualification.
- Bluetooth branding.
- The role of UnPlugFest (UPFs) interoperability testing events.
- Production.

Who This Course Is For

- Marketing
  (all aspects—product planning, commercial, etc.)
- Engineering
  (development, test, hardware, software, etc.)
- Sales
  (so they can ask annoying questions to Marketing and Engineering)

Topic Coverage: Broad, but not In-Depth

- Time constraints.
- Broad, DEEP Bluetooth expertise is rare. If someone tells you they are a Bluetooth expert they might not have an appreciation for the complexity of Bluetooth.
  (Bluetooth Qualification Expert is a questionable choice of title by the Bluetooth Special Interest Group (SIG).)
- I am familiar with many aspects of Bluetooth, but I am NOT a Bluetooth expert. However, I do know more than most people.

Some Of My Bluetooth Experience

- Frequent time with Bluetooth developers, testers, product managers, etc. in U.S., Europe, Japan, and Asia through a combination of site visits and UnPlugFests.
- Work with the Bluetooth SIG to improve the Profile Tuning Suite qualification tool (“the PTS”).
- Attended over 15 UPFs since August, 2001.
- Key contributor to Frontline’s FTS4BT™ Bluetooth protocol analyzer (sniffer) product.
- Speaker at Bluetooth development conferences.

About Frontline

- Involved with Bluetooth since 2000.
- Make and sell FTS4BT, the de facto industry standard for Bluetooth protocol analysis (an important tool used by Bluetooth engineers).
- Formerly, provided worldwide support for the Bluetooth SIG's Profile Tuning Suite product qualification tool.
- Tom Allebrandi (Product Manager) sits on Bluetooth Core Specification Working Group.
- Tom has provided Bluetooth training to numerous engineers, including employees of the Bluetooth SIG.
- Bill Drake (Director of Operations) Chairs Automation Working Group.
- 2006 worldwide sponsor of Bluetooth UnPlugFest interoperability testing events.
- Worldwide distributor for the Codenomicon Bluetooth Robustness Testing Tool.
- Released our Serialtest RS-232/422/485 protocol analyzer in 1988 and have sold tens of thousands of copies.
- Make and sell analyzers for USB, ZigBee, Ethernet, and numerous other industrial communication buses.

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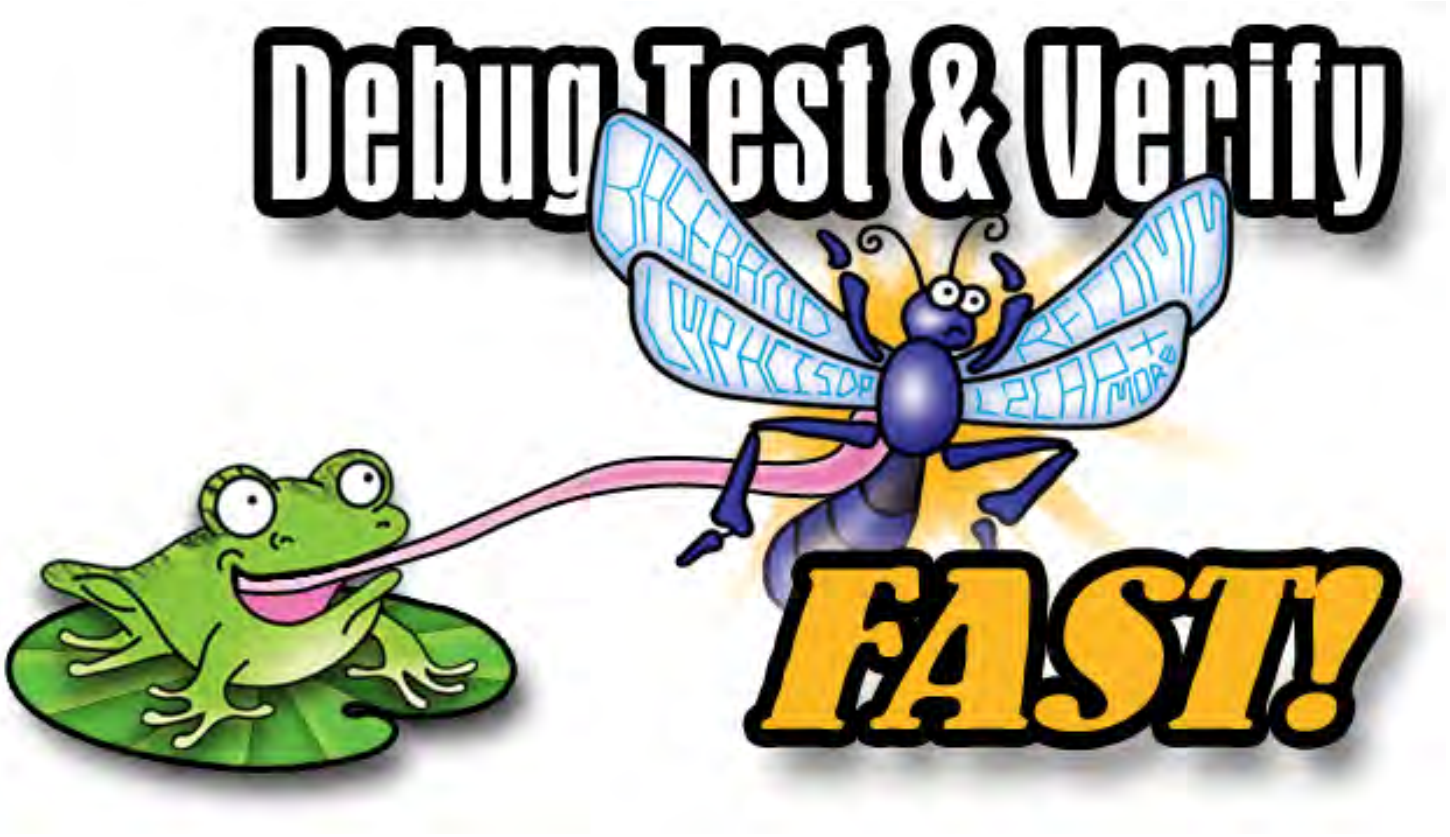
Bluetooth® v2.0+EDR
Multi-mode Protocol Analyzer



Quick Introduction to Bluetooth

- Wireless.
  - ISM band (Industrial, Scientific, and Medical).
    - 2.4 GHz (along with 802.11b/g, IEEE 802.15.4/ZigBee, some portable phones, microwave ovens…).
  - FHSS (Frequency Hopping Spread Spectrum).
  - AFH (Adaptive Frequency Hopping).
- Short distance (< 100 meters).
- Today, low data rate (< 3 megabits/second).
- Future, data rates up to 480 megabits/second).

Quick Introduction to Bluetooth

- Low-cost (< $3/chip in volume).
- Low-power.
- Small physical footprint.
- Good for voice and data (simultaneously).
- Is likely to be in all but the least expensive consumer mobile phones within a few years.

Quick Introduction to Bluetooth

- Operates in piconets consisting of a master and up to 7 slaves.
- Scatternets consist of multiple cooperating piconets, but, with the exception of transient scatternets, their use is not common.
- Fairly strong encryption (up to 128 bits).

Quick Introduction to Bluetooth

- Invented by Ericsson (Swedish communication company).
- To enable Bluetooth to become an industry standard, Ericsson founded the Bluetooth Special Interest Group (“the SIG”), and turned control of Bluetooth over to the SIG.
- SIG membership requires executing membership documents that include patent and trademark agreements.
- Bluetooth technology is royalty-free to SIG members.
- The only way to become a licensee of Bluetooth technology is to be a SIG member.

Quick Introduction to Bluetooth

- SIG Member Categories
  - Promoter
    - Tightly controlled, small number (Agere, Ericsson, Intel, Lenovo (originally IBM), Microsoft, Motorola, Nokia, Toshiba. 3COM dropped down to Associate).
    - Large financial commitment, board seat.
  - Adopter
    - Free.
    - Only major requirement is executing the member agreements.
    - Currently about 7,000 Adopters.

Quick Introduction to Bluetooth

- Associate
  - Any company willing to pay the annual membership fee (currently about 200 Associates).
    - $7,500 if annual revenues < $100 million, $35,000 otherwise.
  - Key benefits
    - Reduced product listing fees.
    - Free use of the PTS.
    - Early access to specifications.
    - Allowed to serve on working groups (and therefore influence potentially important technology and policy decisions).

Quick Introduction to Bluetooth

- For many companies involved with bringing Bluetooth products to market, it makes good economic sense to become an Associate member of the SIG.

Deciding if a Product Should Support Bluetooth

- Today, the most common products that support Bluetooth involve audio.
  - Mobile phones.
  - Hands-Free car kits.
  - Mono headsets for use with mobile phones.
  - Stereo headsets.

Deciding if a Product Should Support Bluetooth

- Up and coming product areas:
  - Introduction of Bluetooth into Sony PlayStation 3 is potentially a market driver.
  - Bluetooth is being used in an ever-increasing range of medical devices, industrial devices, etc.
  - Bluetooth penetration of the PDA market continues to grow.

Deciding if a Product Should Support Bluetooth

- Why wireless?
  - Is it an innovative application that truly takes advantage of being wireless?
  - Reduced cost (connectors and cables generally cost more on a per unit basis than wireless).
  - Convenience (wires are a nuisance).
  - Does wireless improve reliability?
  - Is it safe to be wireless?

Deciding if a Product Should Support Bluetooth

- Why Bluetooth?
  - Are unit volumes high enough to justify both upfront and ongoing costs?
  - Can a premium be added to the price of the product?
  - Does the application play to the strengths of Bluetooth?
  - Does the application avoid the weakness of Bluetooth?

Deciding if a Product Should Support Bluetooth

- Can Bluetooth branding be leveraged?
- Will Bluetooth allow the product to tap into a large installed base? (Currently about 13 million Bluetooth chips are shipping each week.)
- Will supporting Bluetooth speed up time to market or slow it down?
- Is Bluetooth the only wireless technology the product will support?

Deciding if a Product Should Support Bluetooth

- How well does Bluetooth coexist with other technologies that will be in the product?
- Are there ongoing costs related to Bluetooth after the product is shipping and how do these compare with other technologies?

Profiles

- A profile is a use case definition.
- Profiles are used at the application level as a way of specifying high-level functionality.
- Profile specifications define the rules and messaging required to implement a particular application client or server.
- The profile concept reduces the risk of interoperability problems because it defines how devices should work with each other.

Profiles

- Currently there are more than 20 profiles with more on the way.
- Current Examples
  - Hands-Free (HFP) - Procedures allowing a mobile phone or similar device to utilize the hands-free capabilities in an automobile.
  - Object Push (OPP) - A means of transferring business cards, contact information, etc. between phones, PDAs, computers, etc.
  - Dial-Up Networking (DUN) - Allows a device such as a PDA without a network connection to use a nearby mobile phone or computer for access to the Internet.

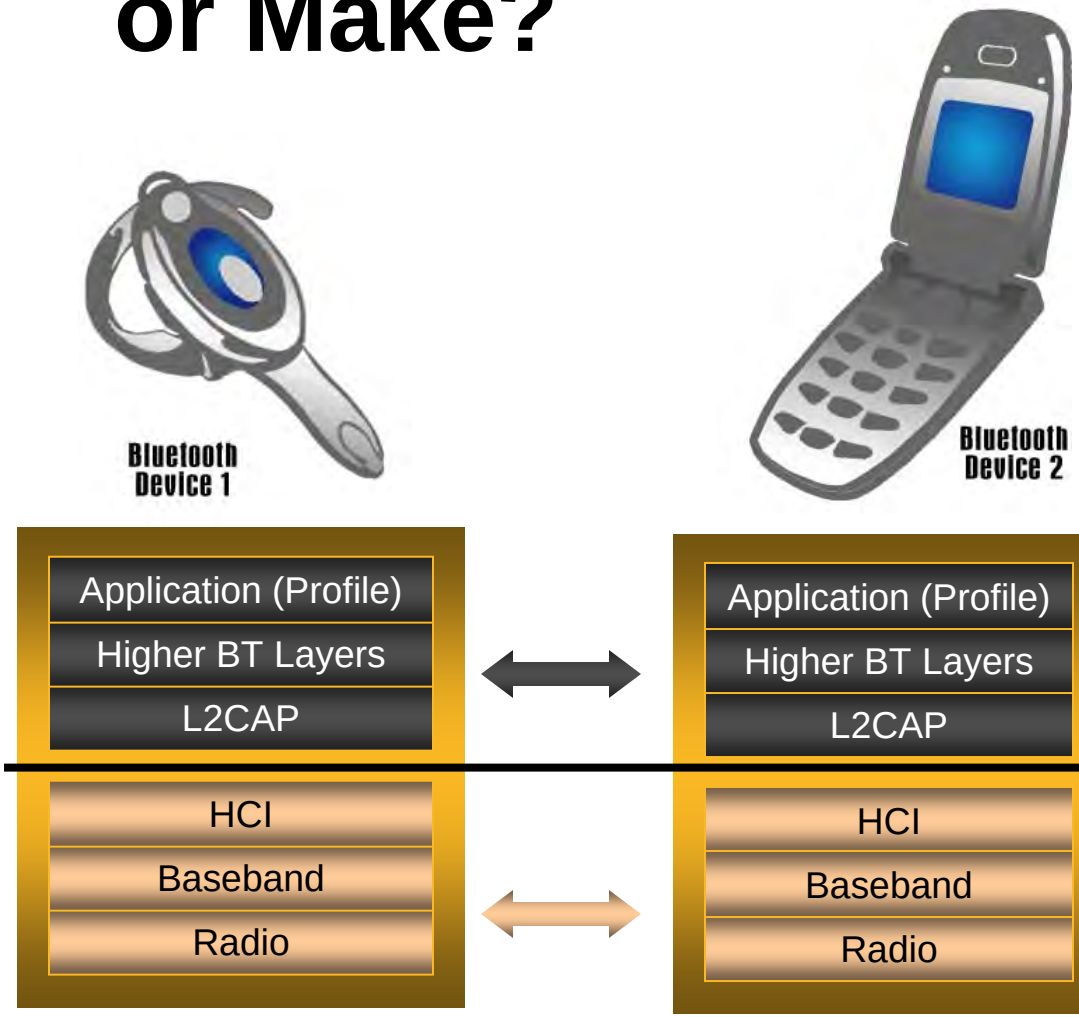
Profiles

- Profiles make it practical for even a low-cost device, such as a headset, to support Bluetooth.
  - Devices only need to support selected profiles.
  - For example, there is no need for a headset to support printing.
  - System resources such as memory and processor speed can be kept to a minimum.

Profiles

- Supporting one or more profiles is a requirement for universal interoperability.
- If universal interoperability isn't a requirement, then profiles don't need to play a role in product definition.
- The SIG encourages the creation of new profile definitions because this increases the potential market size for Bluetooth.

The Bluetooth Stack: License or Make?



- We are going to be discussing the UPPER Bluetooth stack.
- This is L2CAP and above.
- The LOWER Bluetooth stack is almost always provided by the chipmaker.

The Bluetooth Stack: License or Make?

- Deciding which Bluetooth stack to use is potentially the most critical technical decision you will make during the entire process of creating a Bluetooth product.

The Bluetooth Stack: License or Make?

- Key items impacted by stack choice.
  - Quality.
  - Unit cost.
    - Not only software licensing, but other system elements such a memory and processor.
  - Time to market.
  - Composition and size of project team—both development and test.
  - Potentially your choice of Bluetooth chipmaker or module maker will depend on the stack you choose.

The Bluetooth Stack: License or Make?

- Don’t decide to make your own stack without very careful consideration. It is potentially a much larger job than you might expect.

The Bluetooth Stack: License or Make?

- Consider unit cost of the Bluetooth function relative to the overall unit cost of the product.
  - Is it important to save a few dollars on the Bluetooth function if, for example, you are selling a high-end automobile?
    - Have you noticed the Jaguar ads that focus on Bluetooth as a reason to buy?

The Bluetooth Stack: License or Make?

- If you are giving serious consideration to making your own stack, consider the following factors:
  - There is now at least one relatively robust Bluetooth stack available royalty-free in the public domain (BlueZ is a Linux Bluetooth stack).
  - You might be able license a chipmaker's or module maker's stack for as little as FREE.

The Bluetooth Stack: License or Make?

- Even when dealing with a stack vendor that doesn't sell hardware, you might still be able to negotiate a very favorable unit price.
  - Keep in mind that with software licensing, the incremental unit cost to a vendor is usually extremely low, so be prepared to be aggressive in your negotiations.

The Bluetooth Stack: License or Make?

- A hybrid approach could be taken.
  - License the core protocols (L2CAP, RFCOMM, SDP, etc.) and build your own profiles on top.
    - If the stack vendor doesn't already have the profiles that you are implementing, you might be able to negotiate a trade.

The Bluetooth Stack: License or Make?

- Which profiles does your product support?
  - Not all stack vendors support all profiles.
  - Some stack vendors tend to focus more on particular application areas.
- Can you build a better implementation than your competitors' and gain an advantage by giving your users a better experience?

The Bluetooth Stack: License or Make?

- Try to arrange for source code access.
  - It is often useful during debugging.
  - If no immediate source code access, try to get a source code escrow agreement in case your stack vendor disappears.
- A maintenance contracts that provides for bug fixes and upgrades is important.
  - There are bugs in every stack.
  - Bluetooth is ever-changing.
- Your development team should be comfortable with the availability and quality of the technical support because they are going to need support.

The Bluetooth Stack: License or Make?

- Bluetooth chips continue to grow in processing power (general purpose and digital signal), memory size, and integrated functionality (FM radio, for example).
  - This allows more application-level functionality to be done directly on the Bluetooth chip, thereby reducing product unit cost.
  - This will tend to steer the stack decision towards using chipmaker supplied stacks.

Bluetooth Modules

- A Bluetooth module is small printed circuit board that consists of a Bluetooth chip, an antenna, and other components needed to Bluetooth-enable a device.
- Some modules also include a host processor where the Bluetooth application resides.

Bluetooth Modules

- Some module makers will bundle stack software.
  - Their own.
  - The chipmakers.
  - Third party.

Bluetooth Modules

- RF (Radio Frequency) design can be very difficult.
- Using a module is often an effective way to limit the risk of Bluetooth RF problems.
- For some applications, modules can be an effective way to completely isolate Bluetooth functions and therefore simplify overall system design.

Bluetooth Modules

- As a general statement, using modules has very little downside risk, and potentially provides many benefits.
- Even large companies, with a lot of engineering talent and manufacturing resources that are producing mass-market products sometimes use modules.

Bluetooth Modules

- Disadvantages
  - Potentially, same typical ones that come with using any pre-made subsystem:
    - Higher unit cost.
    - Less control.
  - However:
    - Unit cost could actually be lower because of economies of scale (many module makers buy millions of components).
    - You could have a custom module built to your specifications.

Bluetooth Modules

- Potential advantages
  - Better quality.
  - Smaller footprint of Bluetooth subsystem.
  - Reduced engineering risk.
  - Faster time to market.
  - Lower NRE (Non Recurring Engineering charges).
  - Lower unit cost.

Selecting a Chipmaker

- Strictly speaking, a Bluetooth chip isn't needed.
  - Bluetooth IP can be implemented in other ways, such as an ASIC.
  - This approach was being promoted a few years ago, but didn't catch on.

Selecting a Chipmaker

- Some chipmakers have focus areas.
  - TI, for example, is probably most concerned with keeping their mobile phone makers happy.
  - Zeevo, before Broadcom bought them had an audio focus.
- Some chipmakers tend to be earlier to market with support for new versions of Bluetooth.
  - Typically, Broadcom, RFMD (now Qualcomm), and CSR lead the way.
- Chips come in different flavors, differentiated by physical interface (UART, USB, SDIO, etc.), RAM, ROM, etc.
  - Not all vendors supply all flavors.

Selecting a Chipmaker

- Do some chip perform better than others?
  - Every chipmaker knows that they have the best performing chips available and can back it up with convincing data.
  - Do your own tests and try to model your application during the testing.
- When considering price, remember to look at total cost (support components needed, stack, module, etc.).

Selecting a Chipmaker

- Should you choose a chip based on vendor specific functionality (which is allowed using HCI extensions)?
  - Be careful—this could cause problems when selecting a second source chipmaker.
- Today, because chipmakers are often also stack suppliers, a lot of the same analysis you do when evaluating stack choices will be useful as you evaluate chip suppliers.

Selecting a Chipmaker

- Will you be dealing directly with the chipmaker or with a distributor?
  - Dealing with a distributor can be a good thing.
  - Some distributors are willing to play important roles in the design and debug of your product.
    - Probably more likely outside of the U.S.
- Does the chipmaker or the reseller have a reference design that you can use?
  - This can be a large timesaver and money-saver and easily justify paying more on a unit cost basis.
  - Reference designs are often royalty-free.

Selecting a Chipmaker

- It is important for your development team to be comfortable with both the availability and the quality of the technical support because they are going to need support.

Selecting a Chipmaker

- Be sure to have a good understanding of who is going to provide the application engineering support that you are going to need.

Bluetooth Challenges For The Product Team

- Bringing a Bluetooth product to market is potentially a difficult task.
- The exact nature of the product can make a huge difference in the complexity of the task and therefore in the skills and experience needed by the product team.

Bluetooth Challenges For The Product Team

- Potential challenges:
  - RF.
  - Overall complexity of the technology, and, in particular, software and/or firmware.
  - Rapid rate of change to Bluetooth specifications .
  - Qualification.
  - Government certification.
  - Interoperability.

Bluetooth Challenges For The Product Team

- It might not be necessary to have in-house resources for all areas, but it is a good idea to have plans in place for how you would deal with each area, should the need arise.

Bluetooth Challenges For The Product Team

- RF
  - RF performance is sometimes confusing even to RF engineers.
  - Subtle points such as thickness of a plastic case, orientation of an antenna, or the value of a low-level system parameter can have a major impact on system performance.
  - Measure RF performance—don't assume anything.

Bluetooth Challenges For The Product Team

- Complexity
  - Bluetooth is a very complex technology and, in particular, there is a large amount of software and/or firmware involved.
  - Don’t underestimate the level of software expertise needed.
  - Be careful not to fall into this trap: “I’m licensing a stack, and buying a module, so I’m not going to have any issues.”

Bluetooth Challenges For The Product Team

- Rapid Changes
  - I've been involved with Bluetooth since 2000 have been exposed to V1.0b, V1.1, V1.2, V2.0, V2.1 (aka "Lisbon") and the Seattle release.
  - V2.1 products aren't on the market yet and there will be a large amount work required to implement Seattle features (this includes UWB).
  - An additional set of features will probably be announced in March (at the annual All Hands Meeting).

Bluetooth Challenges For The Product Team

- How can you know how Bluetooth changes impact your product unless you know what changes are planned?
- And, even if you know what changes are coming, does this mean that you fully grasp the implications?

Bluetooth Challenges For The Product Team

- Consider the following scenario:
  - You are making a stereo headset and you decide to wait for Bluetooth V2.0 + EDR chips.
  - Your competitor understands that V1.2 provides enough functionality to produce a decent product.
    - Your competitor beats you to market.
    - Your competitor has a lower cost of goods sold because V1.2 chips cost less than V2.0 + EDR chips.

Bluetooth Challenges For The Product Team

- Qualification
  - Qualification is the process of testing a product to ensure that it meets a minimum set of standards, recording the tests results, and having the results accepted.
  - You can't bring a product to market until it is qualified.
  - Qualification is enough of a specialty so that the SIG tests people before granting them the title of Bluetooth Qualification Expert.

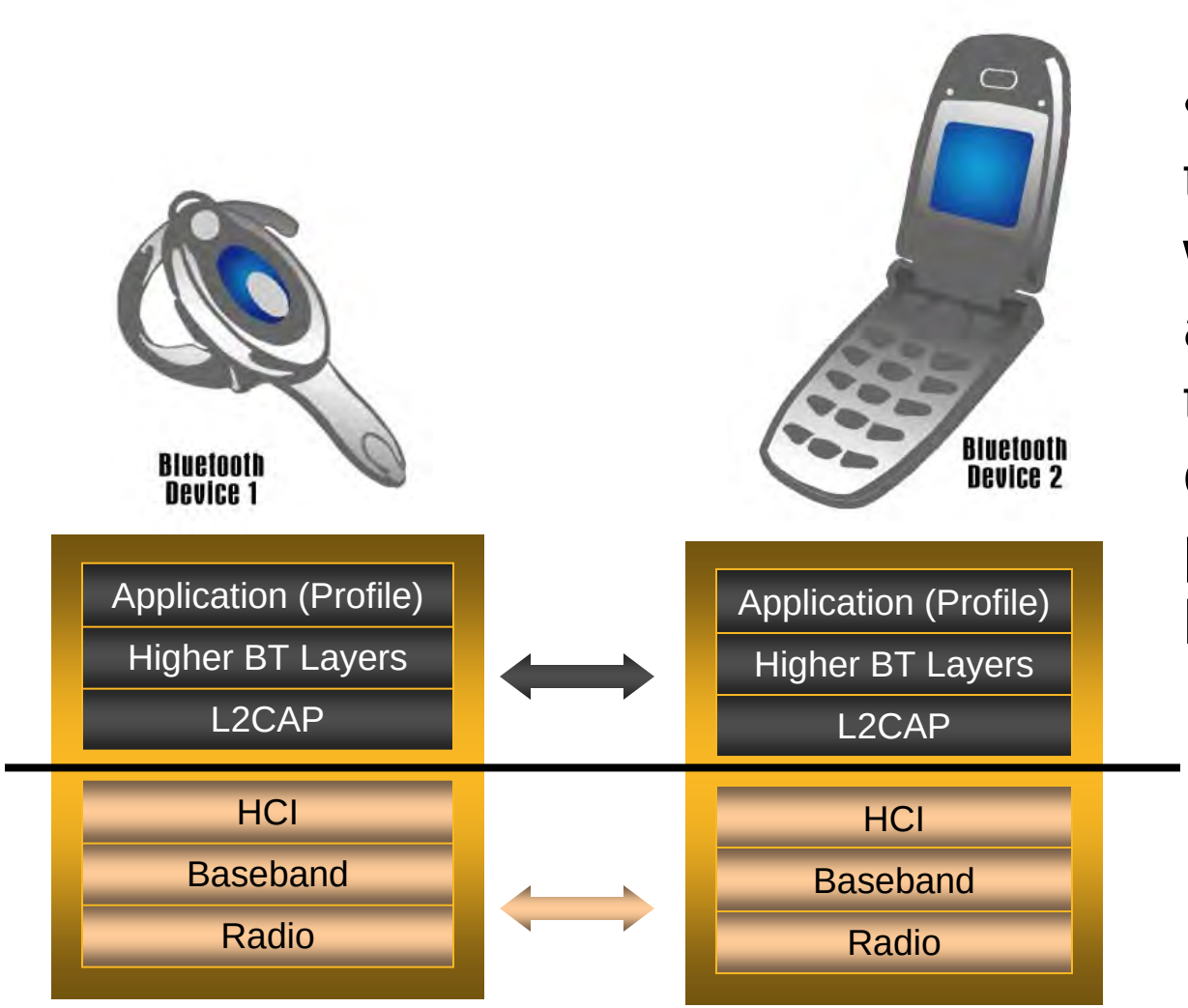
Bluetooth Challenges For The Product Team

- Government Certification
  - Because Bluetooth is an RF technology government certification is a requirement in some markets.
    - FCC in the U.S.
    - TELEC in Japan.
    - Etc.
  - Getting the correct certification for Bluetooth products isn't usually difficult, but does take time and money.
  - You'll probably want to work with a test lab or have your manufacturer take care of this for you.

Bluetooth Challenges For The Product Team

- Interoperability
  - For most products, interoperability is the single biggest technical issue to focus on.
  - Qualification and interoperability are not the same thing.
    - A product can be qualified, but not have a high degree of interoperability.
  - Interoperability testing should be undertaken as early as possible in the development cycle and, ideally, should not be conducted by development engineers.

Product Partitioning



•Partitioning refers to the split between which part of the application runs on the Bluetooth host controller and which part runs on the host CPU.

Product Partitioning

- Some products, such as headsets, are simple enough so that in many implementations there isn't a host CPU required and everything runs on the host controller.
- As Bluetooth chips increase in processing power, this approach is becoming more common.
- Chipmakers are adding more on-chip software functionality and providing it at very low cost as a way to win business.

Product Partitioning

- Advantages
  - Lower cost.
  - Less real estate.
  - Probably lower power enabling smaller battery and/or longer battery life.
  - Reduced part count.

Product Partitioning

- Disadvantages
  - Limited processing power and memory could possibly constrain enhancements.
  - Software debug might possibly be more complicated due to limited visibility.
  - Second sourcing of chips potentially more difficult due to tight binding of application software to Bluetooth baseband implementation.

Product Partitioning

- Partitioning isn't always an "all or nothing" decision.
  - For example, there might be cases when it makes sense to have all the core protocols running on-chip and everything else running on a host CPU.

Product Partitioning

- Unless the partitioning decision is obvious, take the time to think through it.

Development Tools

- Tools such as compilers potentially vary depending on the chips you are using, programming language choice, etc.
- We’re going to discuss generic Bluetooth development tools.

Development Tools

- Basic RF tester.
- Bluetooth production tester.
- Profile Tuning Suite.
- Protocol analyzer (aka Bluetooth sniffer).
- Robustness tester.
- Conformance tester.

Development Tools

- Basic RF Tester
  - A tool for performing basic RF testing, such as a spectrum analyzer, is something that might be useful if you are having trouble with fundamental issues such as two Bluetooth devices connecting.
  - If you work with Bluetooth long enough, you are likely to be glad that you have one of these.

Development Tools

- Production Tester
  - As the name implies, Bluetooth production testers are typically used in a production environment to test the basic Bluetooth functionality of devices as they are coming off the manufacturing line.
  - As with a spectrum analyzer, on occasion, it can be convenient to have one of these.
  - It can be helpful to have the same kind of production tester in development that is used by manufacturing so that development can help manufacturing setup their testing.

Development Tools

- Profile Tuning Suite
  - For many companies the SIG's Profile Tuning Suite will be a very useful tool.
  - For numerous profiles, the product must interoperate with the PTS to get qualified.
  - Eventually, the SIG would like the PTS to be the tool used to perform all profile-level qualification testing.

Development Tools

- The PTS is being enhanced to perform other kinds of tests that will help promote interoperability. Some of these tests are likely to be mandatory for qualification.
- Unlimited license seats for the PTS are free to Associate members. Adopters pay $7,500 per seat.
- Start using the PTS as early as practical in the development cycle. This will save you time as you make your final push to bring your product to market.

Development Tools

- Protocol Analyzer (aka Bluetooth Sniffer)
  - A protocol analyzer is like an x-ray machine for data communications.
  - It is arguably the most important development tool that you can buy for a Bluetooth developer.
  - Be careful not to fall into this trip to convince yourself not to buy one: "I'm licensing a stack, and buying a module, so I'm not going to have any issues."

Development Tools

- Robustness Tester
  - Tests Bluetooth software by sending unexpected and malformed packets.
  - Improved product quality.
  - An excellent way to do automated stress testing.

Development Tools

- Conformance Tester
  - Used for low-level testing, typically by chipmakers.
  - Most companies don’t need one of these and won’t benefit much by having one.

Preparing For Qualification

- Integrate qualification testing into your development plan such that, at the end of the project, qualification is a natural result that almost happens by itself.
- Understand the requirements before making any key decisions.
  - https://www.bluetooth.org/qualification/
- Check your understanding with the right people at the SIG.
  - Get it in writing, clearly spelled out.
  - Don’t get caught by subtle points.

Preparing For Qualification

- Use as many pre-qualified components as possible (chips, modules, stack, etc.).
- If possible, avoid changes that invalidate the qualification of pre-qualified components.
- Understand the fees.
  - Test labs.
  - SIG product listing (deep discounts for Associate members).

Preparing For Qualification

- Build qualification testing into your normal engineering test cycle.
  - This should help avoid last-minute technical surprises.
- Qualification does not imply interoperability.
- Qualification is something you do to comply with SIG regulations.
  - It doesn't help your customers.

Bluetooth Branding

- Be aware that the SIG takes branding very seriously.
- Understand the branding rules and follow them to avoid trouble.
  - https://www.bluetooth.org/bluetooth/landing/brand_tools.php

UnPlugFests

- Interoperability test events for engineers (no marketing, sales, etc.) run by the SIG.
- One week of “round-robin” testing against products brought by other attendees.
- Also, testing against the PTS, hosted by the PTS development team.
- The SIG extensive device library is also available.

UnPlugFests

- One week, three times/year. One each in:
  - Asia
  - Europe
  - North America
- Attended by companies from around the world.
  - Product companies such as Nokia, Motorola, Microsoft. Toshiba, Samsung, etc.
  - Chipmakers.
  - Stack vendors.

UnPlugFests

- These are great events.
  - Discover problems before your customers by testing against pre-release versions.
  - Make potentially invaluable technical contacts at other companies.
  - The best way to learn a lot about Bluetooth in a short amount of time.
- Come!

Production

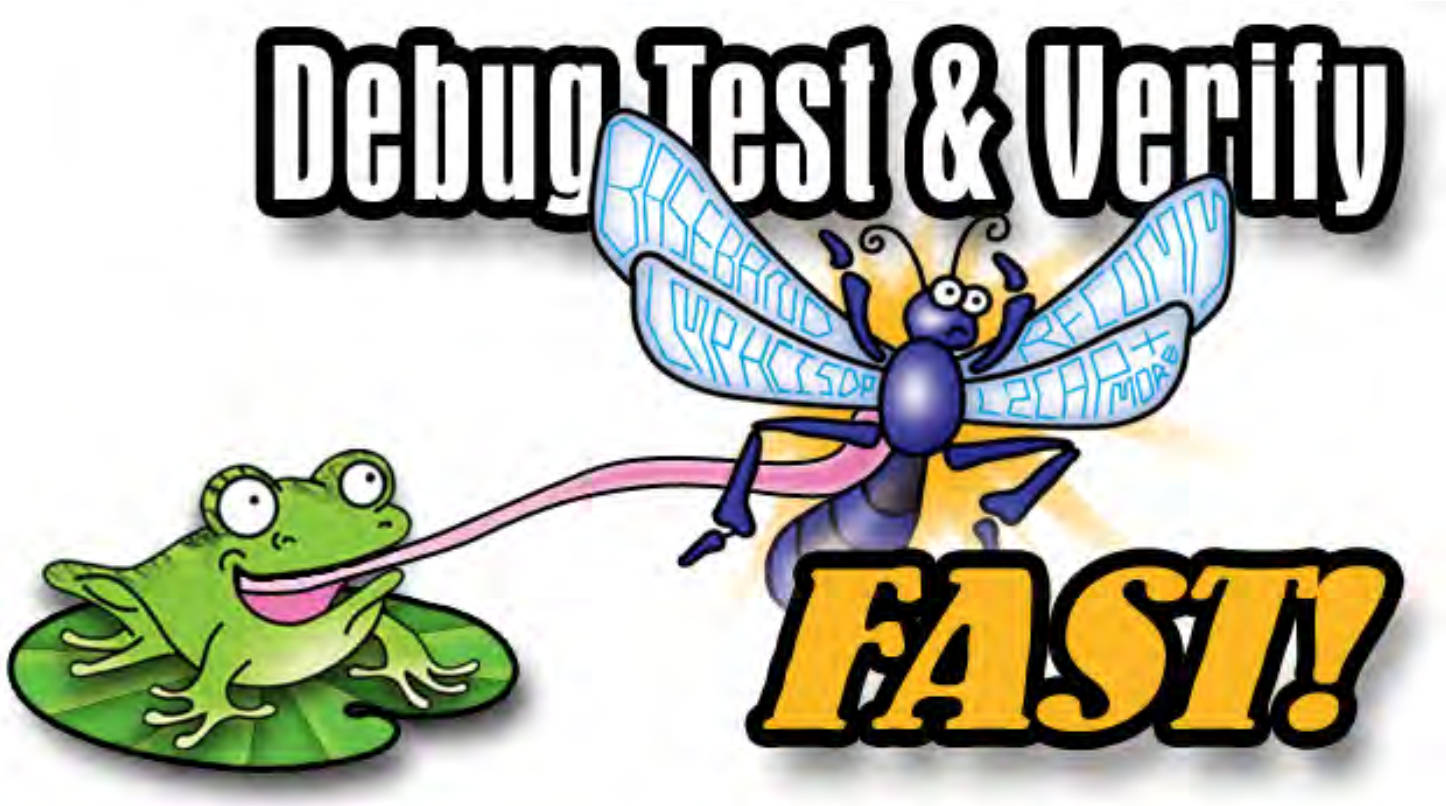
- It is common today to use Original Device Manufacturers (ODMs) to produce Bluetooth products.
  - ODMs are used by both large and small companies.
- ODMs are often located in Asia.
- Working with Asian manufacturers is relatively straightforward and the cost savings can be significant.
- It is becoming more common for ODMs to have sales offices in the U.S. to make it even easier for both the ODM and their customers.

Production

- Try to use a manufacturer that has Bluetooth experience and, if possible, has a relationship with your Bluetooth chipmaker.
  - There are many subtle points and you should do what you can to avoid being a “learning experience”.
- Look for a manufacturer where there is good and efficient communication between your development team and the manufacturers technical team.

Production

- It is important to have clear definition on all aspects of manufacturing test.
- Don’t assume anything.
- Typical financial terms are 30% down when the order is placed and the balance due before shipment.
- Be careful.



Thank You!