ellisys

Better Analysis

Bluetooth Vanguard™

Advanced Wireless Protocol Analysis System

Innovative ▪ Cutting-Edge ▪ Integrated

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Wideband BR/EDR and Low Energy sniffer, with concurrent capture of Wi-Fi, WPAN IEEE 802.15.4, spectrum, HCI (USB, UART, SPI), Generic UART, SPI, SWD, I2C, WCI-2, logic signals, and Audio I2S

Innovative Tool for Demanding Users

The most advanced, most comprehensive Bluetooth® protocol analyzer ever made. Building on a legacy of innovation, the Bluetooth Vanguard All-In-One Wireless Protocol Analysis System delivers new advances designed to ease the increasingly complex tasks of Bluetooth developers.

With its **revolutionary wideband Digital Radio and integrated All-in-One hardware approach,** Ellisys has changed the way Bluetooth protocol capture and analysis is done, by radically overcoming the drawbacks of legacy approaches. The Ellisys wideband capture approach robustly records any packet, at any time, from any neighboring piconet, with zero-configuration and without being intrusive.

Reconfigurable Bluetooth Digital Radio

The reconfigurable radio concept for Bluetooth analyzers is another innovation from Ellisys engineering. With the Bluetooth Vanguard, this cost-saving feature remains a core user benefit. Reconfigurability means that the analyzer can be **updated by software to support new features,** without any change to the hardware. For instance, this flexibility allowed for the addition of Bluetooth features such as enhanced AES Security, Connectionless Broadcast, and more recent features, like Coded PHY and the 2Mbps BLE speed enhancement many months before these features were released in an updated specification.

Additionally, Ellisys analyzers come with **free lifetime software updates** and no restrictions on sharing the application software with co-workers, so our customers can benefit from these great additions hassle-free.

Industry's First Bluetooth Wideband Capture

Bluetooth wireless technology was originally designed to be robustly impervious to interference on the much-used 2.4 GHz ISM band. It was also designed to be difficult to sniff, for security reasons. To meet these criteria, a Bluetooth radio uses from 40 to 79 channels pseudo-randomly according to a hopping sequence defined at the piconet's connection time.

A hopping sniffer tries to actively synchronize on a specific hopping sequence, and captures the packets only after a successful synchronization. This kind of sniffer has several inherent limitations, making it more difficult to use, less reliable, and usable only in a limited set of scenarios.

Ellisys created the industry's first wideband sniffer in 2010, which overcame these drawbacks, adding revolutionary features which opened new horizons for Bluetooth debugging and interoperability testing. The wideband capture approach is as simple as it is powerful: instead of listening to just a few channels, **the sniffer captures all channels concurrently.** The sniffer thus does not need to synchronize to a piconet; it will listen passively to all nearby Bluetooth piconets, scatternets, and other topologies without any required configuration.

The All-in-One Sniffer Concept — Another Ellisys Innovation

Capturing wireless traffic is a very important aspect of Bluetooth debugging, but other information is equally important for understanding the big picture. This is another aspect where Ellisys sniffers excel.

The Bluetooth Vanguard supports one-click concurrent and tightly synchronized capture of:

Wireless Capture

- Bluetooth Low Energy
- Bluetooth Classic (BR/EDR)
- Wi-Fi IEEE 802.11a/b/g/n/ac (3x3) [ENT]
- WPAN IEEE 802.15.4 [ENT]
- 2.4 GHz Raw Spectrum Energy [PRO]

Wired Capture

- Bluetooth HCI (UART x2, USB x1, SPI x2) [PRO]
- General Purpose Logic Signals [PRO]
- Audio I2S [PRO]
- Wireless Coexistence Interface 2 [PRO]
- Generic Communications –UART, SPI, I2C, SWD [PRO]

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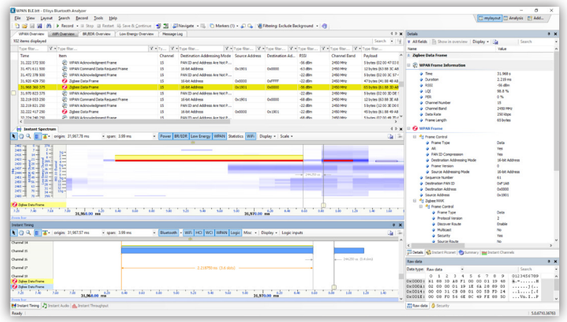
Powerful Ellisys Features

- **All-in-One:** Fully hardware-integrated, time-synchronized, and truly one-click concurrent capture of BR/EDR, Bluetooth Low Energy, Wi-Fi, WPAN (IEEE 802.15.4), raw RF spectrum, HCI, logic/GPIO, generic I2C, UART, SWD, and SPI, Audio I2S, and WCI-2
- **Widely Acclaimed Software:** The Ellisys software application provides intuitive understandings of complex protocol and RF behaviors, and flexible configuration and control to give engineers the insights they need
- **Bluetooth Wideband Capture:** Easy and rock-solid capture of any traffic on all channels, including discovery/connection traffic and complex topologies
- **Wi-Fi 802.11 a/b/g/n/ac (3x3) Capture:** Extremely accurate and perfectly synchronized Wi-Fi capture accelerated by Ellisys hardware protocol engine for best-in-class performance
- **WPAN 802.15.4 Wideband Capture:** Concurrent capture of all 16 WPAN 2.4 GHz channels for an unmatched coexistence analysis capability
- **Connection/Power Flexibility:** Connect, control, and power the system locally or remotely via networkable GbE (with Power-over-Ethernet/PoE) or USB 3.1 over Type-C® (with USB Power Delivery)
- **Emerging Features Support:** Benefit from early implementation of pre-specification feature additions
- **Mesh Support:** Includes full support for Bluetooth Mesh network topologies
- **Reprogrammable Bluetooth Digital Radio:** Support for new specifications without hardware changes
- **Multi-Piconet Support:** Visualize all topologies, including multiple piconets and scatternets
- **All Protocols and Profiles:** Best-of-breed protocol decoding
- **Integrated Audio Analysis:** Listen to captured over-the-air audio, including audio over HCI and I2S, within the software, in sync with all other traffic
- **Raw RF Spectrum Display:** Characterize the raw wireless environment and visualize coexistence issues
- **Free Maintenance:** Free lifetime updates as well as free fully-featured viewer software with unlocked hardware that can be used on any computer

All-Channels 802.15.4 WPAN

IEEE 802.15.4 is a technical standard that provides lower-layer support for higher-layer network specifications like Thread and Zigbee. Increasingly, this Low-Rate Wireless Personal Area Network (LR-WPAN) technology is being used on devices, modules, and SoC's that also employ Bluetooth and/or Wi-Fi communications, and in environments like Smart Home, smart cities, and industrial applications where Bluetooth and Wi-Fi are also present.

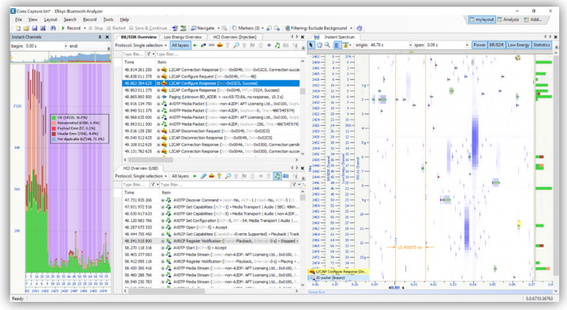
These circumstances present coexistence challenges. **Bluetooth Vanguard uses an innovative wideband approach to capture all 16 WPAN channels** that are used in the 2.4GHz band, including associated RF characteristics, in precise synchronization with all other traffic streams captured by the analyzer.



Visualizing Coexistence Issues

In addition to Bluetooth Classic and Bluetooth Low Energy, Vanguard supports capture of Wi-Fi 802.11a/b/g/n/AC 3x3, WPAN 802.15.4, and raw RF spectrum - **in precise synchronization with each other and all supported wired transmissions.** These technologies are frequently sources of interference and contention with Bluetooth communications, as they share the 2.4 GHz ISM spectrum used by Bluetooth. Increasingly, these technologies are co-resident on the same SoC.

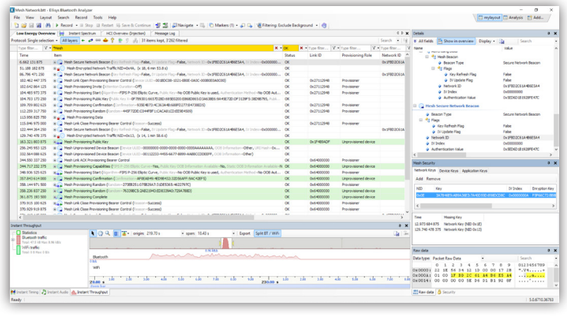
To fully characterize coexistence issues, Vanguard delivers a variety of features that make this task easier. The user is provided a precise understanding of RF signatures, sources, and power, various timings, device performance indications, and other related metrics.



Bluetooth Mesh Networking

The Bluetooth Mesh Networking specifications define a broad spectrum of device and system requirements for a large-scale many-to-many network using Bluetooth Low Energy wireless technology. Bluetooth mesh networks can greatly increase the range of Bluetooth communications by using a message relay approach and are inherently uncomplicated and inexpensive to deploy, as there are no requirements for a central router or computer.

Bluetooth Vanguard provides **comprehensive support for capture of mesh network protocol,** related packet and transactional decodes, encryption and key management features, and error detections. Mesh traffic is captured concurrently and in precise synchronization with all other supported traffic streams.



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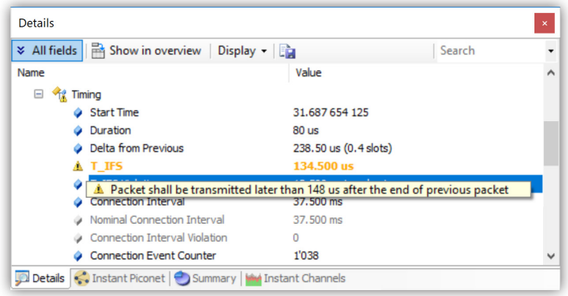
Automated Error Detections

The analyzer software alerts the user to a variety of errors detected for both wired and wireless captures. Physical, protocol, and profile layer errors, including packet and transactional errors, are **automatically highlighted without any need to search through the capture.**

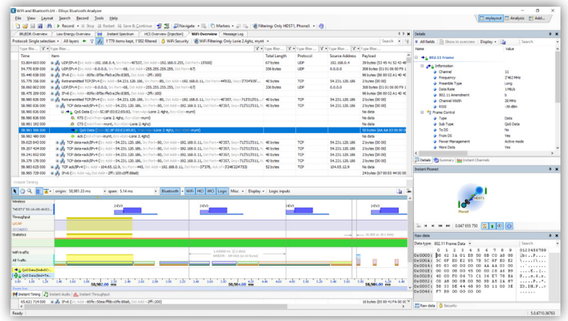
Errors are highlighted on a color-coded system to indicate the relative severity of the errors, summarized in a dedicated status column in each protocol overview, and described in the Details view or with pop-up messages on fly-over in the Overviews. Incomplete payloads, missing or incorrect field values, center frequency violations, timing violations, missing responses, and CRC errors are among the errors indicated.



Wi-Fi Capture - Accelerated

With Vanguard, **Wi-Fi traffic is captured using an innovative, Ellisys-designed hardware-accelerated protocol engine.** With lower-performance Wi-Fi capture tools that use a software-based capture approach, the capture process is done with a processor involved. This approach can limit the speed and timing accuracy of the capture – packets can be missed when the processor is outmatched by the incoming streams.

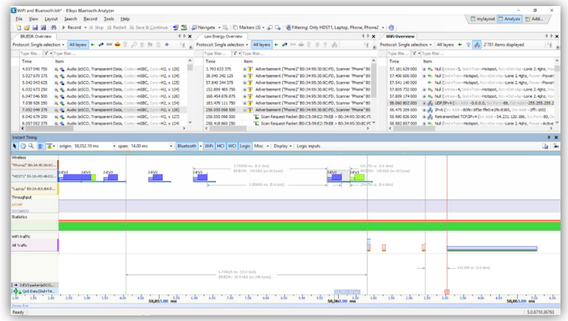
With Vanguard's specially designed protocol engine, the Wi-Fi capture is driven directly and without processor dependence to guarantee throughput and minimize latency. Importantly, the Wi-Fi traffic is captured concurrently and in precise synchronization with all other supported wired and wireless capture streams.



Instant Timing

Timing is everything as they say, and with Bluetooth, it's always an important focus. Multitudes of timing parameters defined by the Bluetooth specification are system-critical. It is understandably important to characterize these timings efficiently and accurately. Hardware and software timing issues are often the source of interoperability and performance issues that can challenge Bluetooth engineers.

The Instant Timing view displays various information along a common timestamp, including visualized Bluetooth, Wi-Fi, and WPAN packets, HCI traffic (UART, SPI, and USB), generic communications (SWD, I2C, UART, and SPI), and logic signals. Data throughput and packet transmission statistics are included to complete the approach.



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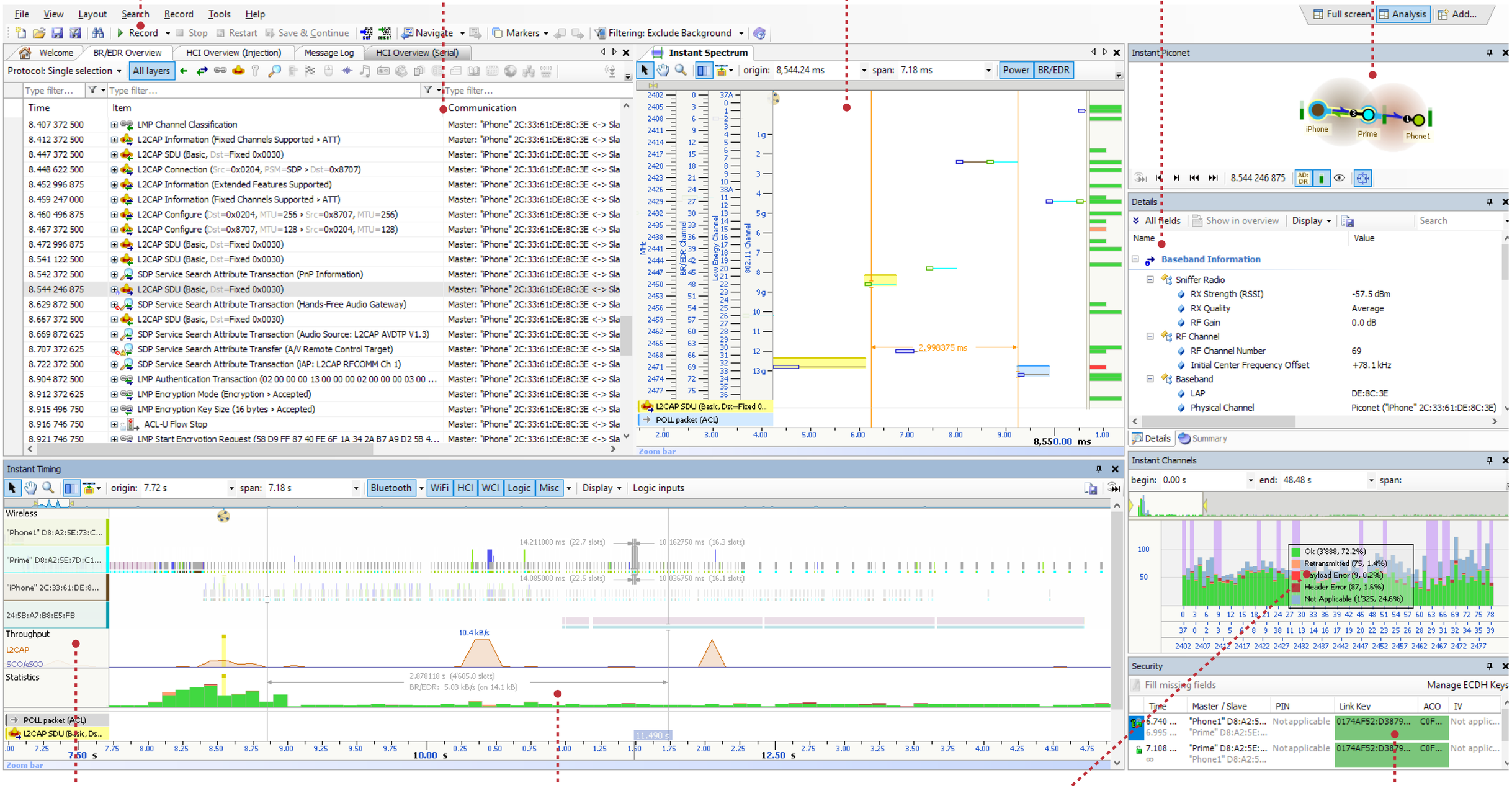
One-Click Record
Capture starts instantly without any configuration. Devices under test are automatically detected.

Protocol Overview
Low-level and stack protocol elements are hierarchically displayed in easily configurable views.

Instant Spectrum
Visualize hopping sequences, AFH dynamics, statistical per-channel error characteristics, timings, and RF characteristics.

In-Depth Data Mining
Detailed meta-data and protocol fields are clearly displayed and linked to the selected item in the overview.

Instant Piconet
Actual piconet and scatternet topology is shown with throughput and other various hints. Works in Live or Replay mode.



Innovative Data Groups
Relationships between packets are made clear, by assembling data per piconet's master device, slave, channel and more.

Instant Timing
Time-ordered, color-coded display of air and HCI traffic, statistics, data throughput and logic signals, with precision timing measurements.

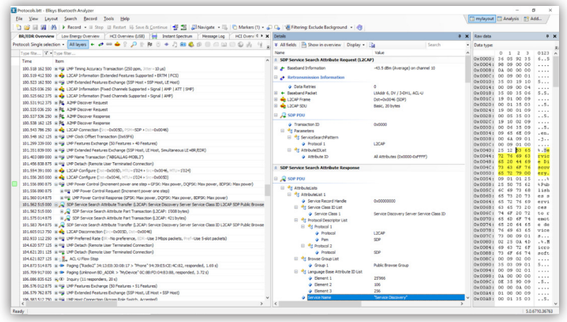
Instant Channels
Understand per-channel transmission quality with a variety of statistics, over a user-specified time range.

Security Management
Manage addition of link keys here. See when a Start Encryption exchange happens and navigate there with a single click.

Protocol & Profiles Analysis

Bluetooth protocols and profiles are displayed in an **easy-to-understand, high-level procedures-oriented chronological format** in the Overview windows and fully detailed to the lowest bit/byte level in the linked Details view. All supported traffic streams are displayed in designated Overviews real-time, as the capture progresses.

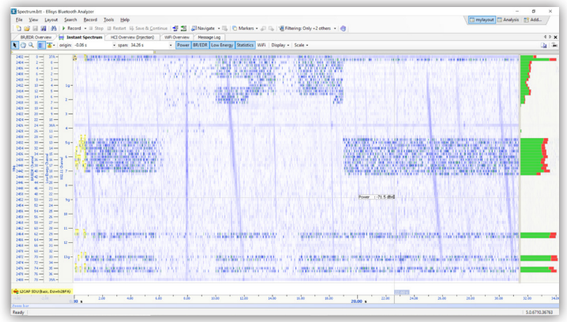
The user is provided various controls to easily customize any Overview, including powerful filtering and coloring capabilities designed to quickly isolate specific protocols, profiles, or communications of interest. Traffic can be presented at the highest level of abstraction and the user can drill down to show all intermediate levels, down to the most basic elements, such as packet-only views.



Spectrum Analysis

The Instant Spectrum feature displays packets by channel, over time and can also **synchronously display raw RF spectrum information in the busy and unlicensed 2.4GHz ISM band** in which Bluetooth operates. Other users of this band include Wi-Fi, LTE, ZigBee, ANT, microwave ovens, and other products and technologies. These users can and do interfere with each other, and it is often necessary to gain a precise understanding of the wireless environment.

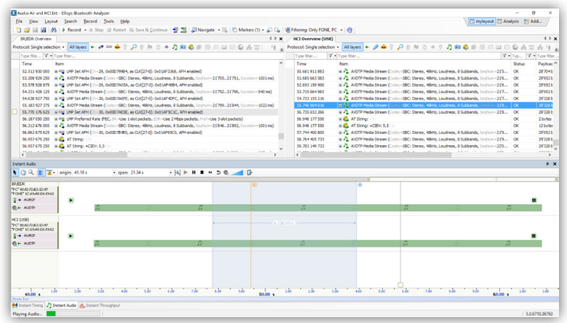
The signal strength of all emitters (RSSI) is displayed. Adaptive Frequency Hopping (AFH) behaviors are overlaid, enabling a keen understanding of the complexities of the dynamic RF challenges encountered by any given Bluetooth link.



Integrated Audio Analysis

The Ellisys analysis software includes integrated Audio analysis. **Any captured audio stream can be quickly and easily played back, even live, during capture.** Finding the packet carrying a specific audio portion or seeing event and topology changes at specific audio positions becomes child's play.

Audio captured over HCI or from an Audio I2S input [PRO] can be played back as well. This enables characterization of the complete audio chain, from the uncompressed audio provided to the source radio chip, to the audio transmitted wirelessly, and the decoded audio received by the receiver radio chip. The various audio streams are exportable to WAV format.



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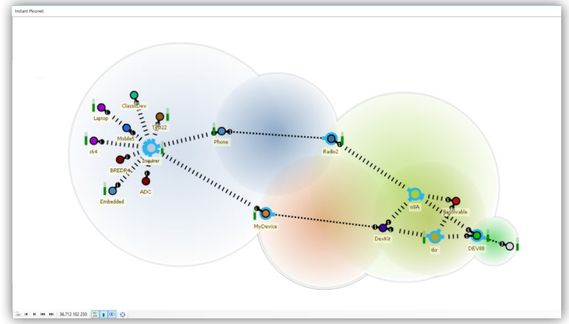
Topology Analysis

Bluetooth technology has become very popular among consumers and continues to evolve into new applications and markets, leading to more complex use cases. The only way to support these new use cases is to create more complex topologies, for example, Mesh Networking.

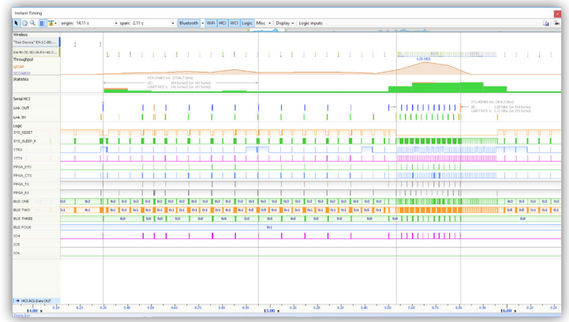
Debugging complex topologies has always been a difficult task, but Bluetooth Vanguard is up to the task with its **powerful wideband radio capable of capturing any traffic from any device,** including the most complex topologies. The Instant Piconet view helps developers visualize their topologies live while capturing, and also provides a play-back feature showing step-by-step evolution of topology changes.



Logic Analysis

The logic analysis feature allows for synchronous capture of external logic signals. Any digital signal is supported, including general-purpose inputs/outputs (GPIOs) or dedicated pins such as TX/RX Active, CTS, RTS, etc. A convenient color-coded probe is supplied.

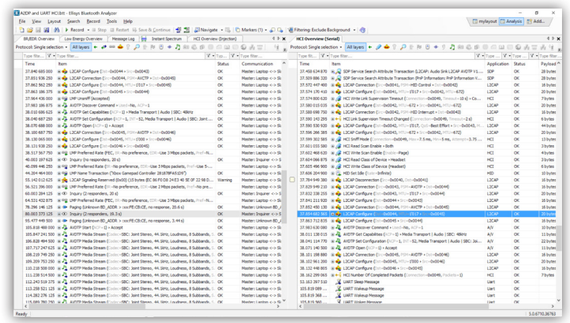
These **signals are visualized with 5-nanosecond precision** and displayed in the Instant Timing view with all over-the-air and wired traffic streams. Signals can be assigned custom names and colors for easy identification. Custom signal groups can be created and displayed as buses, in addition to the display of discrete signals. Users can create simple external comparators and observe thresholds being crossed for various metrics, such a power consumption.



HCI Analysis

Wireless traffic is the primary element of debug information for Bluetooth engineers, but Host Controller Interface (HCI) traffic can be an equally important complement of information for getting a clear and complete picture of a given situation. Bluetooth Vanguard supports capture of HCI transports over USB, UART, and SPI.

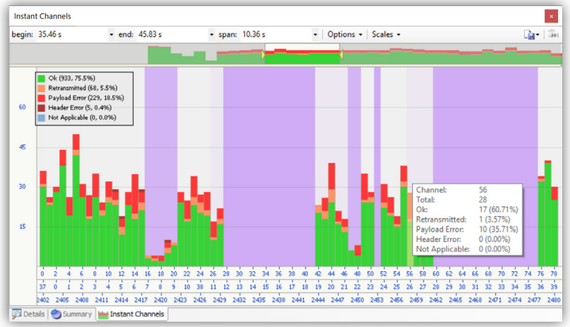
HCI traffic is captured concurrently with the wireless traffic and other wired streams using the same precision clock for perfect synchronization and timing analysis and is decoded and displayed in various formats. Conveniently, the Ellisys software **automatically extracts any Link Key exchanged over HCI** and uses it to decrypt the wireless traffic, all without any user interaction.



Instant Channels

The Instant Channels feature provides **easy-to-understand visual and statistical analyses on various per-channel transmission characteristics,** including packet retransmissions, header errors, and payload errors. This information can be useful in understanding where in the Bluetooth spectrum all devices, or specific devices, are communicating and the spectral areas (channels) they are avoiding, generally due to external interferences.

Visual cues are provided to give the user an understanding of the propensity of a given device, or aggregate devices, to avoid particular channels. This information is provided for the duration of an entire capture and can be configured to characterize all devices in the vicinity or specific devices.



Instant Throughput

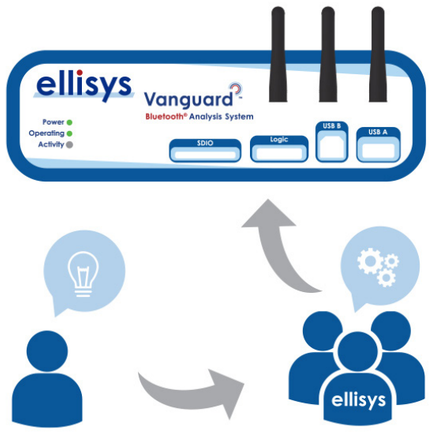
Understanding device data throughout performance is a common task for wireless engineers. These metrics are the domain of the Instant Throughput view, which **provides throughput by device and by L2CAP or SCO/eSCO channel and Wi-Fi communications.** A convenient statistical overlay provides information on how various transmission inefficiencies may be affecting throughput, such as packet retransmissions.

Each device and channel is color-coded and can be shown or not shown as the user may prefer. A navigation bar is provided to allow the user to select a time range to pan through the entire capture to see trends, as well as high and low peaks on data throughput.

Emerging Features Support

All Ellisys Bluetooth analyzer systems are reconfigurable with software updates – another Ellisys innovation. Ellisys maintains close relationships with radio developers worldwide and with various technical groups involved in outlining new Bluetooth specifications.

This approach allows new features to be added even in the conceptual stages, long before they become standardized in a public release of the Bluetooth specification. This is a huge advantage to Bluetooth radio developers, and to the Bluetooth developer ecosystem in general, as radio developers can test new features well before they are committed to silicon, greatly reducing chances of re-spins or discoveries of issues in the marketplace, post-spin.



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Configurations and Purchase Information

Radio Configuration	EDR	LE	DUAL
BR/EDR Capture	x		x
Low Energy Capture		x	x

Editions	Standard	Pro	Enterprise
Wideband Bluetooth Capture	x	x	x
HCI Capture		x	x
Logic Capture		x	x
I2C, UART, SPI, SWD Capture		x	x
Spectrum Capture		x	x
Audio I2S Capture		x	x
WCI-2 Capture		x	x
Wi-Fi 802.11 a/b/g/n/ac Capture			x
WPAN 15.4 Capture			x
Warranty	2 years	2 years	3 years

Description	Code
Ellisys Bluetooth Vanguard Standard BR/EDR	BV1-STD-EDR
Ellisys Bluetooth Vanguard Standard Low Energy	BV1-STD-LE
Ellisys Bluetooth Vanguard Standard Dual Mode	BV1-STD-DUAL
Ellisys Bluetooth Vanguard Pro BR/EDR	BV1-PRO-EDR
Ellisys Bluetooth Vanguard Pro Low Energy	BV1-PRO-LE
Ellisys Bluetooth Vanguard Pro Dual Mode	BV1-PRO-DUAL
Ellisys Bluetooth Vanguard Enterprise BR/EDR	BV1-ENT-EDR
Ellisys Bluetooth Vanguard Enterprise Low Energy	BV1-ENT-LE
Ellisys Bluetooth Vanguard Enterprise Dual Mode	BV1-ENT-DUAL
Ellisys Bluetooth Vanguard Pro Upgrade	BV1-PRO/UPG
Ellisys Bluetooth Vanguard Enterprise Upgrade	BV1-ENT/UPG
Ellisys Bluetooth Vanguard Dual Mode Upgrade	BV1-DUAL/UPG

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Technical Specifications

Bluetooth Capture Characteristics

- Ellisys Rainbow™: Industry's first wide-band concurrent capture of all Bluetooth channels.
- Frequency band: 2.402-2.480 GHz
- Sensitivity range: From -90 to +15 dBm
- Gain: Programmable from -30 to +30 dB
- Modulations: All BR/EDR/LE modulations (GFSK 1/2Mbps, p/4-DQPSK, 8-DPSK)
- Baseband: Support of Bluetooth 5.x, upgradeable by software. Preliminary support of non-released specifications available.

Wi-Fi Capture Characteristics

- IEEE 802.11 a/b/g/n/ac (3 streams)
- Channel width 2.4GHz: 20MHz, 40MHz
- Channel width 5GHz: 20MHz, 40MHz, 80MHz
- 11n MCS: 0 to 23 (up to 3 streams)
- 11ac MCS: 0 to 9 (up to 3 streams)
- Guard Interval: 800ns (long) and 400ns (short) GI
- Frame encoding: BCC, LDPC, STBC, Greenfield
- Max AMPDU size: 65,535 bytes
- Timing accuracy: 125 ns

WPAN Capture Characteristics

- IEEE 802.15.4-2011
- Channels: All 16 2.4 GHz channels (11 to 26)
- Data rate: 250 Kbps
- Modulation: O-QPSK
- Timing accuracy: 125 ns

Logic Capture Characteristics

- Maximum bandwidth: 20 MHz
- Sampling precision: 5 ns
- Supported input voltage: 1.8 to 3.3V

HCI Capture Characteristics

- USB transport: Low, Full, and High Speed, with automatic detection
- UART transport: Up to 8 Mbit/s, automatic detection of all parameters
- SPI transport: Up to 8 Mbit/s, automatic detection of all parameters

Embedded Memory

- 512 MB of FIFO memory
- Data is stored in highly optimized format
- Analyzed data is uploaded in real time

Low-speed Serial Capture Characteristics

- UART: Up to 8 Mbit/s automatic detection of all parameters
- SPI: Up to 8 Mbit/s, automatic detection of all parameters
- I2C: Up to 1 Mb/s
- SWD: Up to 8 Mb/s

Timing

- Clock: ±10ppm frequency accuracy over -10 to +60 degrees Celsius range
- BR/EDR/LE timestamp accuracy: ±125ns
- Wi-Fi timestamp accuracy: ±125ns
- WPAN timestamp accuracy: ±125ns
- USB HCI timestamp accuracy: ±16.7ns
- Logic timestamp accuracy: ±5ns

Power Adapter

- Input: 100-240 VAC
- Output: 24 VDC
- Power: 40 W
- Plug: 5.5 x 2.1 x 12 mm barrel straight
- Safety: CB, TUV, UL, CCC, PSE
- EMI: CE, FCC, VCCI, RCM

Front-Panel Indicators

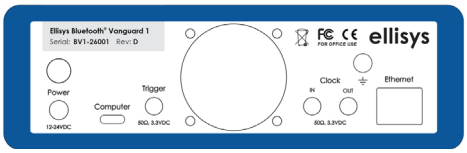
- Power: unit powered on
- Operating: unit performing requested task
- Activity: blinks when wireless or wired activity detected

Front-Panel Connectors

- RF (x3): Shared between Bluetooth, Wi-Fi and WPAN
- USB HCI: USB 2.0 Standard-A and Standard-B
- Logic: Supports UART/SPI HCI, WCI-2, generic I2C/UART/SPI/SWD and logic analysis
- SDIO: Optional, for external trace storage and unit recovery

Rear-Panel Connectors

- Computer: USB 3.1 Gen 1 Type-C
- Ethernet: 1GbE, PoE+
- Power: 12-24 VDC, max 36W
- Trigger: SMA in and out, 50 Ω, 3.3VDC
- Clock IN: SMA, 50 Ω, 3.3VDC, 10MHz
- Clock OUT: SMA, 50 Ω, 3.3VDC, 10MHz
- Earth: Optional, to ground the unit



Power Inputs

- DC input (12-24 V)
- USB Type-C Power Delivery
- Power-over-Ethernet (PoE+)
- Backup Battery (22 Wh)

Enclosure

- 180 x 170 x 58 mm (7.1 x 6.7 x 2.3'')
- 1.5 kg (3.3 lbs)

Hardware Upgrade

- The Ellisys Rainbow™ engine is automatically updated with each software release (no user intervention required)

Maintenance and Licensing

- Free lifetime software updates – no maintenance fees
- Free full-featured viewer software – easily share annotated traces between computers and colleagues
- Use Ellisys hardware on any computer – no additional licenses needed

Warranty

- Two-year limited warranty [STD and PRO]
- Three-year limited warranty [ENT]

Minimum Requirements

- Intel Core, 2 GHz or compatible processor
- 4 GBytes of RAM
- 1280 x 1024 display resolution with at least 65,536 colors
- USB 2.0 EHCI host controller
- Windows® 7 or higher

More information at: www.ellisys.com/bv1

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