

CASE STUDY

Comarch Experience in Bluetooth



Comarch is ready to provide services in the following areas:

- Bluetooth Classic, Bluetooth Low Energy (BLE Mesh, BLE Audio) and Dual-Mode solutions
- Hardware development consultancy
- SW and FW architecture advisory
- Firmware development (stack development (controller, host), application development)
- Integration of various sensors into wearable audio devices, for example, touch sensors with gesture recognitions, proximity sensors, accelerometers, active noise cancelling implementation and TWS implementation

Comarch, besides commercial projects, has its own R&D department focused on training and implementing projects based on the latest Bluetooth standards.

Knowledge and ability to implement the latest Bluetooth features:

- 5.2 (e.g., BLE Mesh, LE Audio, Auracast)
- 5.4 (e.g., ESL, PAWR, Encrypted Advertising Data)
- 6.0 (e.g., Channel Sounding, Ranging Service, DBAF)
- Integration with real-time operating systems (FreeRTOS, Zephyr)
- Companion apps development (web, mobile (iOS, Android, hybrid))
- Interoperability testing
- Quality assurance as an integral part of other services
- On-site production line support

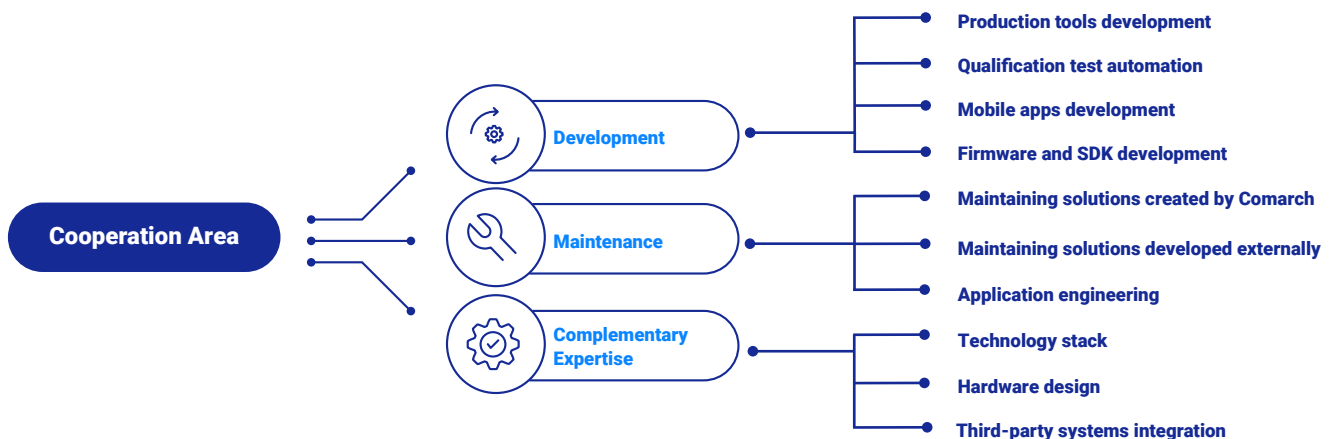
Comarch and Silicon Labs Cooperation



Long-term
cooperation
since 2013



Comarch competencies for Silicon Labs



Firmware Development and Maintenance for Wireless Connectivity Modules - Bluetooth Classic, BLE, Dual Mode

Selected project tasks:

- Design and implementation of various features for wireless modules
- Fixing reported bugs and provide technical feedback and support for developed functionalities
- HomeKit integration with BLE and OpenThread stacks
- Testing and verifying current implementation against vulnerabilities reported for BT LE, BR/EDR
- Automation of tests against BT SIG qualification tool for BT Mesh devices

Renesas and Comarch worked together to further develop and improve the TWS-based chip solution. Comarch provided a hands-on experienced team of engineers, members of which were specialists in software and firmware development, especially in audio technologies, such as True Wireless Stereo and wireless connectivity using dual-mode Bluetooth Low Energy and Bluetooth Classic solution.

Comarch's role:

- Integrator for the project
- Implementation of the audio framework
- Implementation of stream synchronization between headphones
- Implementation of a mechanism for extracting audio packets to relieve the main computing unit
- Preparation of test applications for all types of audio streams (BLE, BLE Audio, Bluetooth Classic)
- Bluetooth stack debugging

Services for Packetcraft (Bluetooth 5.2 and 5.4 stack)



Comarch's responsibilities:

- Support implementation process of PAWR (Periodic Advertising with Responses BLE 5.4 feature) by creating automated tests and helping with firmware implementation – focused in Controller layer of the Bluetooth stack (Link Layer, HCI (Host-Controller Interface), PHY (Physical layer))
- Creating test plans and strategies for firmware implementation
- Support implementation process of OTP (Object Transfer Profile) service
- Executing EBQ (Ellisys Bluetooth Qualifier) test cases and checking logs
- Working on RAM memory usage and code size optimization – dynamic allocation to reduce static memory if possible, creating unions from few structures, structure variables alignment, reuse of unused buffers, etc.
- Working with other BT features such as CTE (Constant Tone Expression), PA (Periodic Advertising), EAD (Encrypted Advertising Data)
- Maintenance of existing controller test cases (LL (Link Layer)/HCI Test Suites) - valid with official bluetooth link layer test cases and creating new ones to ensure great product quality
- Planning and creating new vendor specific test cases to validate custom features
- Introducing new upgrades to existing test framework to automate executing test scenarios in a more efficient way
- Continuous work on Bluetooth stack development (features such as CIS (Connected Isochronous Stream)/BIS (Broadcast Isochronous Stream) and others) in cooperation with an international team

Scope of Work and Key Activities:

- **External BLE Host Porting** – integrated into Zephyr’s Bluetooth subsystem with necessary build system modifications.
- **Host Selection Mechanism** – enabled developers to choose between Zephyr’s default BLE Host and the external stack at build time.
- **Translation Layer** – implemented conditional compilation for seamless sample application compatibility across multiple BLE Hosts.
- **HCI Driver Integration** – ensured smooth communication by integrating the external BLE Host with Zephyr’s HCI drivers.
- **CI/CD Pipeline** – established pipelines for build validation, PTS qualification tests, and power consumption analysis.
- **Demo Applications** – developed sample apps to validate BLE functionality, including BLE audio streaming on nRF5340 Audio DK with Google Pixel 7.

Tier 1 Customer (Consumer Audio)

Bluetooth headset (A2DP, HFP, AVRCP, proprietary profile)

- Firmware development
 - CSR8675
 - Cypress DSP chip (other functionalities)
- Development of additional non-standard functionalities
- Integration of libraries from different suppliers
- Codecs integration and external codecs optimization
- Quality assurance
- Manufacturing test tools development
- Production line support

Bluetooth headset with telemetric (A2DP, HFP, AVRCP, proprietary profile)

- Firmware development
 - CSR8675
- Quality assurance
- Manufacturing test tools development
- Production line support
- Companion application development for PC and mobile
 - Firmware upgrade
 - Headset configuration
 - Telemetric acquisition

Bluetooth ear buds (A2DP, HFP, AVRCP, proprietary profile)

- Bluetooth connection between each ear bud for stereo audio
 - Qualcomm family chip
- Integration of various sensors
 - touch sensors
 - proximity sensor
 - accelerometer
- Over the air update
- Charging case SW developed from end to end
- Non-standard communication between charging case and ear buds

Hearing Aid Platform Development

For Comarch, the project started with building a testing platform as the basis for the further development and verification process for the client. Simultaneously, we ran hardware tests in search of possible improvements. After presenting the results to WSA, we assisted with fixing issues. The next step was to develop the device low level drivers in C++ and implement Bluetooth module support for the audio stream services. We have also provided the test framework to ensure the usability and to support the further implementation of planned features.

Automotive Bluetooth Transmitter – TIER 1 Automotive Company

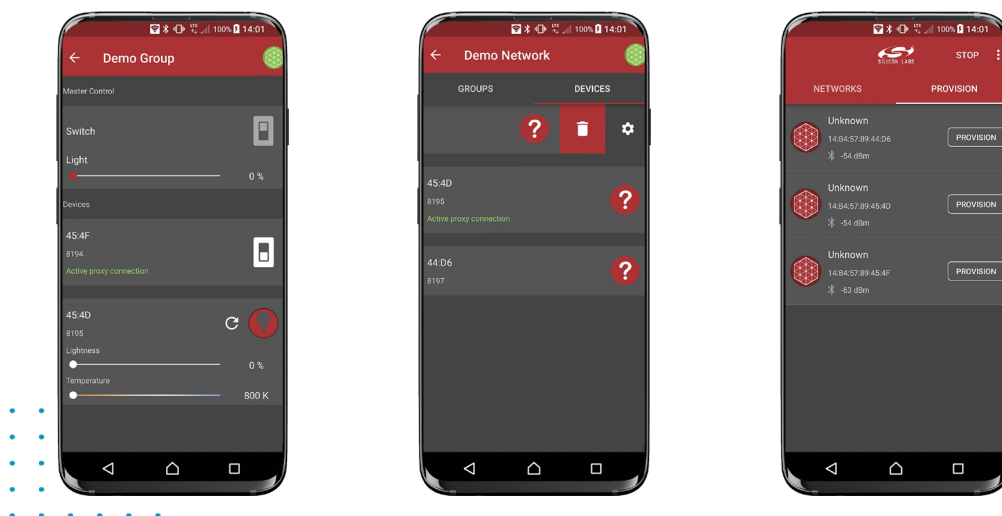
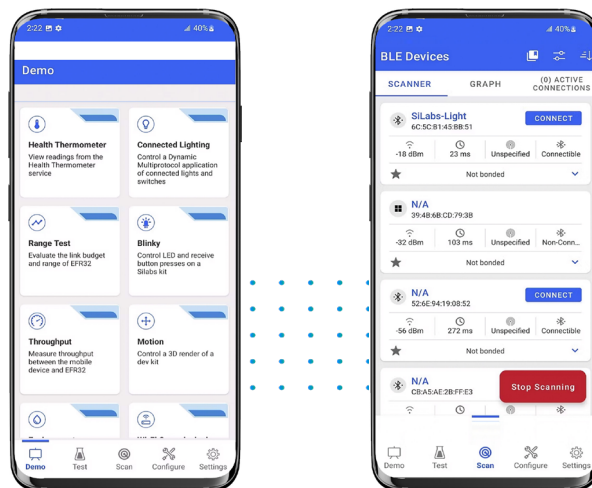
Project scope:

- System architecture, Bluetooth firmware design, MCU to Bluetooth module protocol design
- Implementation of Bluetooth transmitter module
- Deliverables: binaries, software release notes, software code, software documentation, test results, error reports
- Transmitter MCU mock simulator (UART communication for testing)
- Complete and independent project management including setting up development environment for Comarch tasks
- Hardware review and HW issues resolving support
- Complete QA
- BT SIG certification support (including internal PTS test).
- Delivering documentation for implemented SW and related processes
- Onsite workshops, hardware prototypes bring-ups (four HW versions)
- Project started with incomplete scope, flexible approach to delays in the project due to HW delays

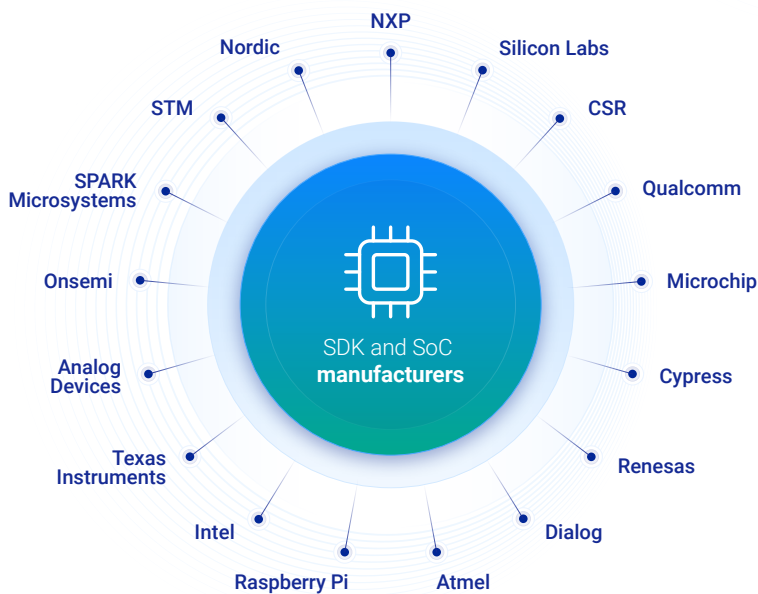
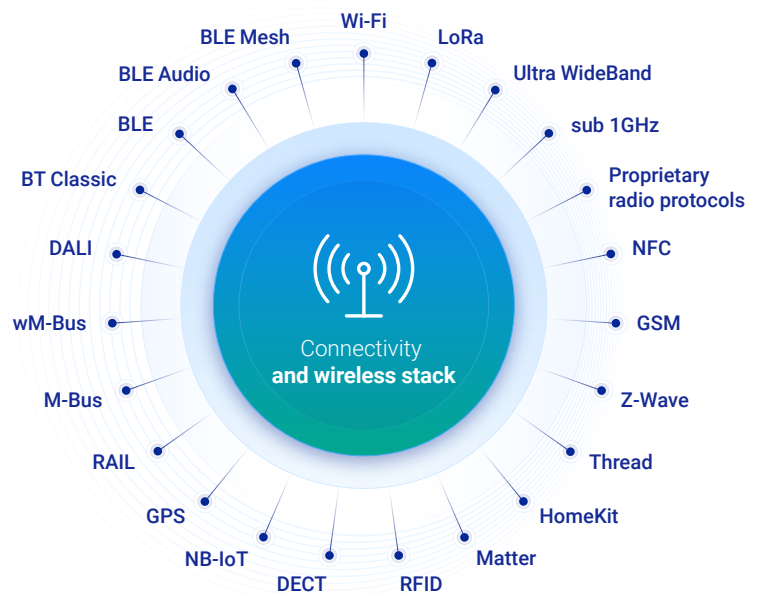
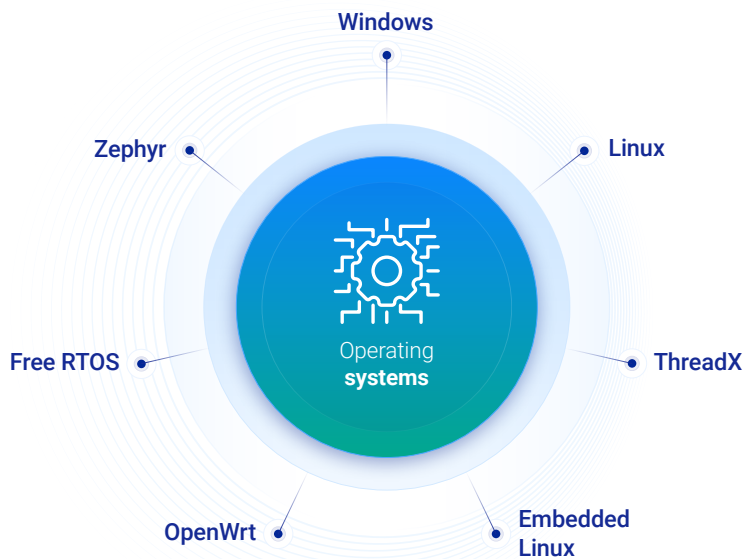


Companion Apps

- Companion apps delivered for leading consumer electronics and premium audio OEM's
- Including mobile apps development takeover from other provider
- Mobile and desktop applications for device management
- Reference applications for connectivity modules manufacturer, for example:
HomeKit implementation, BLE Mesh



Comarch's expertise and experience with other technologies:



COMARCH

Comarch is a well-recognized and stable company on the global market. There are 7000+ experienced technical employees worldwide and thus can answer any demands for resources.

Comarch Software and Hardware Services is the combination of expert, high-quality, end-to-end solutions for global clients and partners. Our team consists of specialists and engineers with a deep understanding of clients' needs in the areas of software development, connectivity, integration, quality assurance, interoperability, and cross-platform services. Our vast knowledge of modern technologies, supported by a combination of hardware and software, helps us to deliver a comprehensive, individual approach in each project. Through several years of cooperation with market leaders, we have gained experience much needed to equip your company with desired solutions. We guarantee an individual approach regarding the form of cooperation, and our role and visibility in the project. When it comes to IPR, we are flexible to the point that we can transfer it to the client after the project ends.

To discover more about how Comarch's expert, high-quality Software and Hardware Services can be tailored to meet your specific business requirements, we encourage you to reach out to us. Our dedicated team is prepared to offer personalized assistance and lead you through the potential of leveraging our cutting-edge solutions for your organization's prosperity.

Contact us now to embark on a transformative journey towards innovation and growth.



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