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Blinky-Lite Integrated Control System Overview

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Integrated Control System Definition

An integrated control system (ICS) is more than just a collection of graphical user interfaces (GUIs) to be displayed on computer monitors inside a control room. For systems that require high reliability, an ICS must contain the following functions:

- System configuration protocol including
  - Data structure (scalar, vector, image…)
  - Alarms
  - Timestamps
  - Naming convention
- System communication protocol
- Alarm handling including notification and action0.5
- Database for data archival and retrieval
- Access Control for setting and reading
- User application framework
  - Standard applications such as
    - Plotting packages
    - Alarm screens
    - Access and settings history
  - Custom application framework

However, many control platforms such as EPICS, TANGO, LabView are not complete frameworks but provide a subset of functions required in an ICS. For example, EPICS provides a system communication protocol (Channel Access), a library of device drivers, and some GUI building tools. But it does not contain built-in data archiving, alarms handling, and access control requiring the user to add these features at significant development cost.

The Blinky-Lite integrated controls platform developed by BL-MC AB does contain all of the required functionality of a complete integrated control system. The only tasks required in implementing a custom Blinky-Lite controls platform are filling in the system configuration protocol and developing custom applications required by the user.

BL MONITOR & CONTROL

Company Overview

BL Monitor and Control AB is a spin-off company from MaxIV and the European Spallation Source accelerator laboratories in Lund, Sweden. We have over forty years of combined experience working at big science facilities. Our expertise covers a wide spectrum of fields from electronics design, RF engineering, renewable energy, ultra-high vacuum technology to software programming, cloud computing, machine learning, and web application design. We have implemented control electronics and applications for the LHC, the European Spallation Source, MaxIV light source, and Fermi National Accelerator Laboratory.

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Blinky-Lite Control Platform

BL-MC has developed a control system platform called Blinky-Lite that is ideally suited for facilities composed of systems running widely disparate control protocols as often found in collaborative endeavors. Blinky-Lite is based on Internet of Things (IoT) technology which allows for rapid and flexible deployment at a low cost. Using IoT technology, allows Blinky-Lite to place powerful intelligence close to devices that require control. This close proximity of local intelligence greatly improves reliability without heavily centralized control over as in most standard control platforms. If desired, Blinky-Lite central services such as device database, application server can also be securely hosted on the cloud resulting in low cost maintenance and rapid service agreements.

Blinky-Lite Overview

The Blinky-Lite architecture is shown in Figure 1. All devices are packaged in “cubes”. While Blinky-Lite provides a standard cube controller protocol, cubes do not need to use this protocol. For example, the cube controller protocol could be in EPICS, LabView, ModBus,etc. A number of cubes communicate with a message “tray”. The communication protocol could be done in a number of ways such as UART, I2C, SPI, TCP, etc.

The location of the message tray is usually (but not necessarily) in close physical proximity to the device cubes. Ths permits the use of medium speed feedback loops between the device cubes connected to a message tray. The message tray translates the cube data into the Blinky-Lite format which is a structured JSON object and transmits (or receives) the data to the Application Box. The JSON object is both human and machine readable and can contain many different scalar, vector, and tensor data types.

There can be many message trays communicating with the Application Box. The message trays communicate with the application box using MQTT which is a publish-subscribe protocol. Publish-subscribe eliminates the need of polling which can overburden the device cubes and can miss transient changes in state of the device cubes. The application box writes the device data into a non-sequential database for alarm scanning and data archival. The application box also contains device routers where device data can be immediately published to user applications. Also the MQTT broker facilitates communication between different message trays and device cubes. A major function of the Application Box is as a server for the built-in and user applications. These applications communicate with the Application Box with secure websockets giving a very responsive user experience.

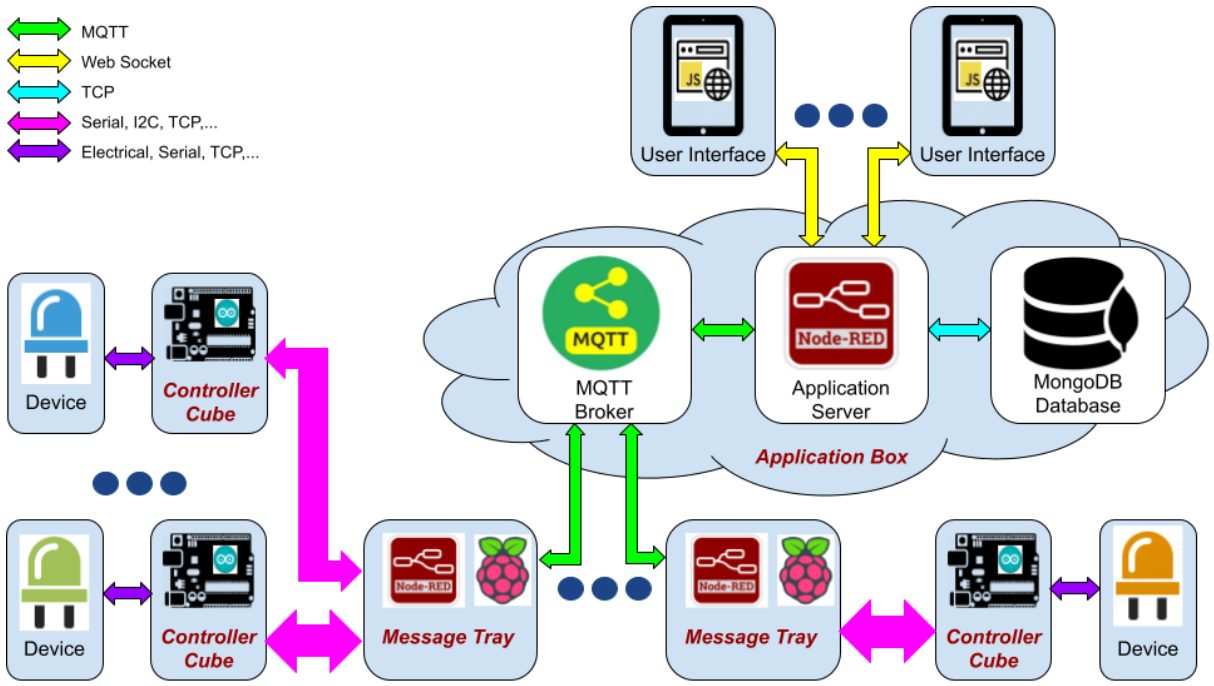

Figure 1. Overview of the Blinky-Lite platform.

Blinky-Lite Features

Built-in Archiver

Unlike popular control platforms such as EPICS, The Blinky-Lite platform also comes with a data archive system directly built into the system. The archival rate is easily configurable along with the ability to easily add new archivable attributes to any device. Archiving data is not just limited to scalar data but also vector data such as waveforms and image data as well. There are several archive retrieval plotting packages built into the Blinky-Lite including a plotter for vector data. In addition there are built in interfaces for data export to Excel spreadsheets and Jupyter notebooks.

Multi-level Alarm Monitoring

Alarm monitoring is crucial for reliable operations but in most other platforms, it is often not included or is an add-on. In Blinky-Lite alarm monitoring is integral to the system. In fact, in Blinky-Lite alarm monitoring is performed on the device level where mobile notification can be configured and is also performed as soon as data is received into the central service. Mobile alarm notifications can be easily configured for each scalar attribute of a device and built-in alarm monitoring application is also provided.

Publish-Subscribe Communication Protocol

Blinky-Lite uses a publish-subscribe communication protocol between devices and central services instead of device polling as used in EPICS. Data polling can often lead to missing crucial transitions of device state and in addition can lead to overburdening low level devices

with too many status requests. With the Blinky-Lite publish-subscribe communication protocol, data is published only when needed and the subscription assures that data is received promptly by either the device or central service. In addition, the publish-subscribe communication server provides an additional layer of security with encrypted communication and authentication. Also connections to the publish-subscribe communication server can only be initiated internally giving an added layer of security.

Role Based Access

Instead of leaving user access to the IT infrastructure of the facility, Blinky-Lite implements role-based access control for all central services such as device settings, database access, and application access. The access system is based on SON Web Tokens (JWT) which prevents access by malicious parties but also, every user is defined a specific role for each application or central service which helps prevent "good people from doing bad things" to the control system.

Web Based Applications

A major difference between Blinky-Lite and every other control platform is that all Blinky-Lite user applications are web applications. Installation of native applications on users computers is a major security risk and limits the type of operating systems that can access the application. In addition, new features and maintenance of native applications is extremely difficult. Because of the availability of extremely powerful and secure browsers, Blinky-Lite uses only web applications. This gives the user instant access to the latest version of the application anywhere and on any device. As mentioned above, all applications are secured through role-based-access based on JSON Web Token technology.

While the Blinky-Lite framework makes it straightforward to build custom user applications, Blinky-Lite comes with eight utility web applications that cover most of users requirements:

- Device Viewer
- Scalar Plotter
- Scalar Archive Plotter
- Vector Plotter
- Vector Archive Plotter
- Alarm Scanner
- Access Logger
- Settings Logger

Blinky-Lite Scalability

While Blinky-Lite is a powerful control platform and has been used to control systems as complicated as particle accelerators. However it is designed to have a small footprint so that it can be easily used on much smaller systems such as home weather systems. The size of the complete source code is on the order of 75MB which comes zipped in a 4 MB file. While many features of Blinky-Lite can be cloud hosted, Blinky-Lite can also be run on a stand-alone computer inside a firewall. The stand-alone computer can be as small as a Raspberry Pi but can also run on any standard desktop computer. Blinky-Lite is operating

system independent. It works on Linux, Mac, or Windows operating systems. Blinky-Lite can operate perfectly fine in a wireless or wired environment if desired.