# Process automation

## Human-machine interfaces (HMI)

BS UNI studies, Fall semester 2024/2025

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# Outline

- Introduction to HMI and SCADA Systems
- Evolution and Applications of SCADA
- SCADA Components and Functions
- Data Visualization, Alarms, and Reporting
- SCADA Software and Tools

# Introduction

- Individual processes are controlled by programmable logic controllers (PLCs)
  - They are programmed for manual and automatic control of the process
  - They are usually spatially distributed across production
  - Information is difficult for operators to access and understand
- Human-Machine Interface (HMI) systems have evolved as user-friendly displays of the control system's operation
  - Buttons and lights
  - Displays, consoles, panels
  - SCADA systems
- SCADA (Supervisory Control and Data Acquisition)
  - Collects information from controllers and displays it in a simple and clear way
  - Enables the operator to intervene in the process (in an easy way)
  - An important element is generating alarms, which draw the operator's attention and allow for quick reactions

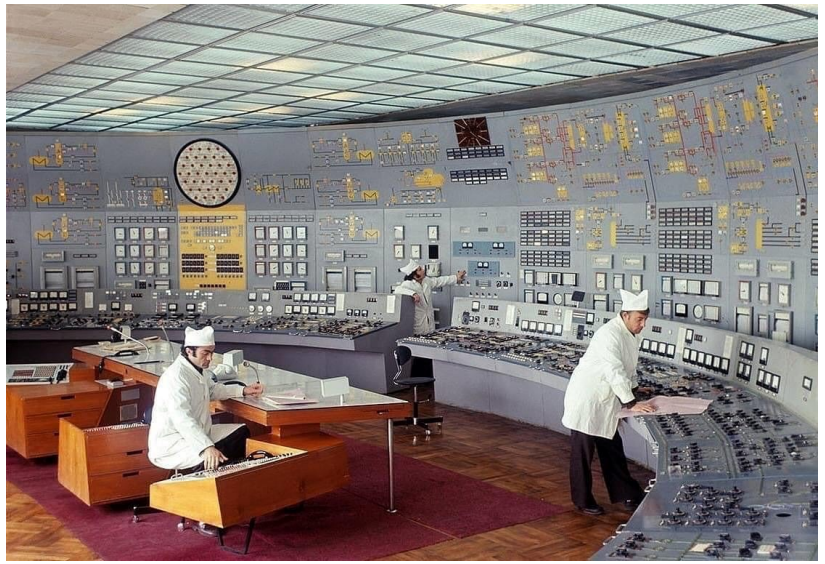
# Basics

Two meanings:

- SCADA as a comprehensive control system
  - Monitoring station MTU (Master Terminal Unit) – limited to supervisory control
  - Peripheral input/output devices RTU (Remote Terminal Unit), PLC – automatic process control
  - Equipment for data acquisition and executing actions (sensors and actuators)
  - Communication network
- SCADA as a monitoring system (our interpretation)
  - Monitoring is the real-time assessment of the technological process's status
  - As part of monitoring, the operator must:
    - Observe the measured data in the process
    - Detect deviations from normal conditions
    - Make assumptions about the possible causes of irregularities
    - Take action in exceptional situations
    - Correctly assess the condition when there are irregularities or insufficient accurate data

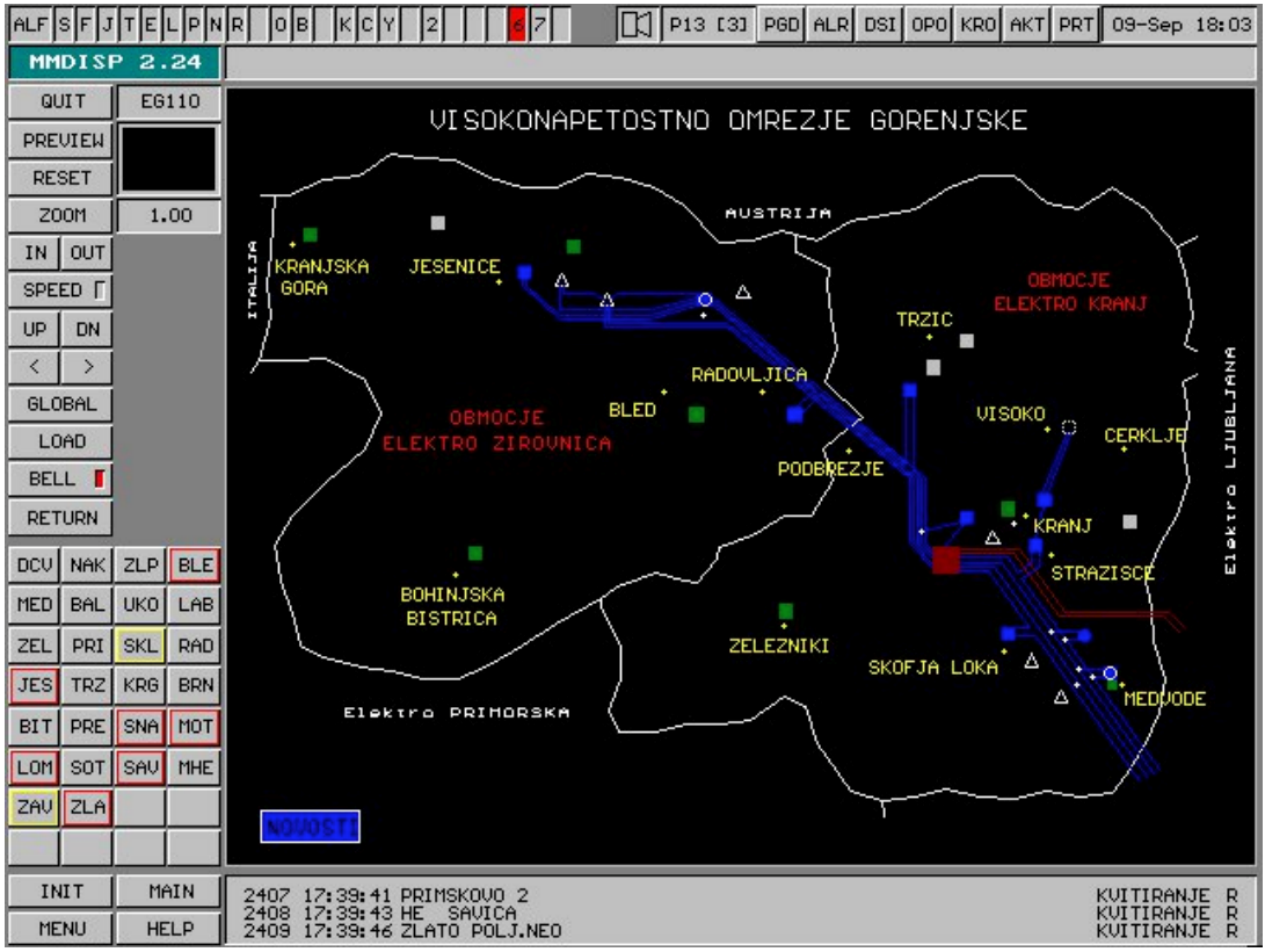
# Development

- **Beginnings: 1960s**
  - Data acquisition and transmission over long distances
  - Early systems were more centralized:
    - Power plants, dispatch centers
  - More frequent operator interventions
  - Relatively expensive
- **1973: the term SCADA**
- **Today:**
  - With the falling cost of computing equipment, SCADA systems have become increasingly accessible, even for smaller applications.
  - More autonomous lower levels, distributed systems
  - Less operator intervention



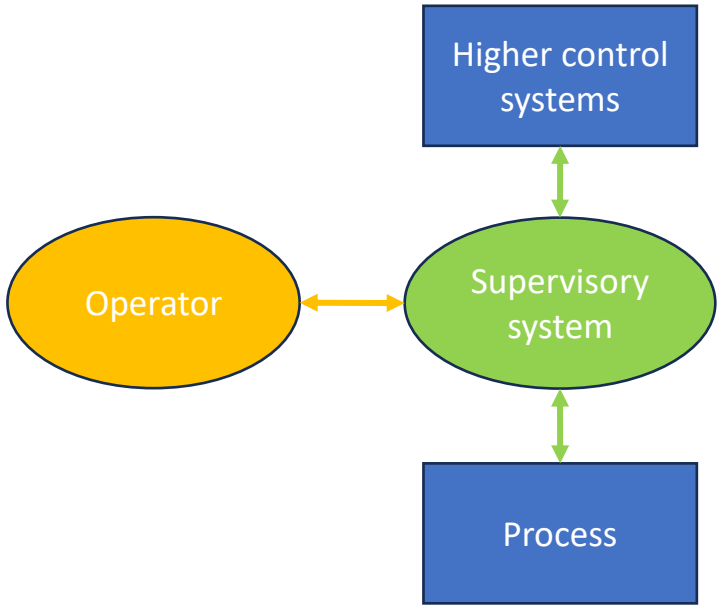
# Areas of Application

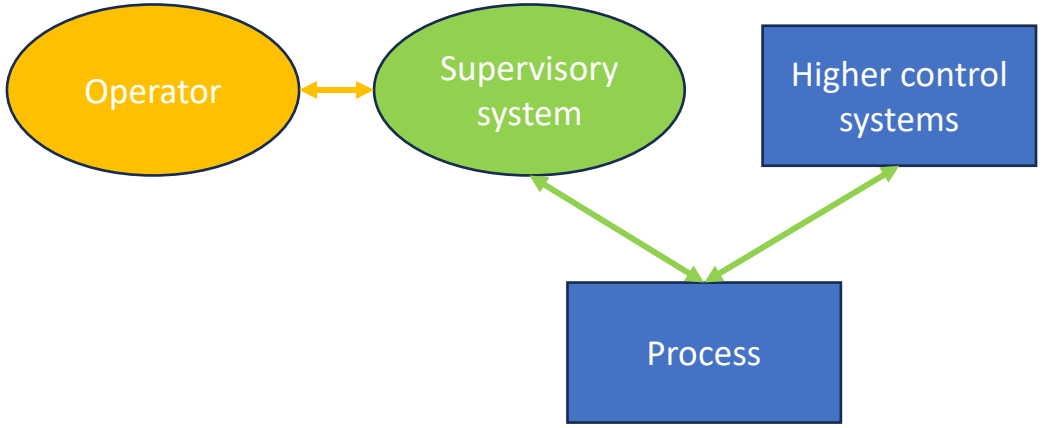
- Distribution systems
  - Electric power, gas, water
- Transport
  - Railways, highways
- Power plants
- Telecommunications
- Laboratories, experimental systems
- Manufacturing systems
  - Automotive industry, chemical, refineries, dairy industry, etc.



# Integration

- SCADA is an addition to the control system
- Linking element:
  - between the process and the operator, as well as between process control and higher-level control systems.
  - Newer paradigms (Industry 4.0) suggest a different model where the supervisory system is parallel to the higher-level control systems, which have direct access to process controllers.
- Control systems provide support to the operator.
- Lower levels must function independently in case of supervisory system failure.



# Manufacturers

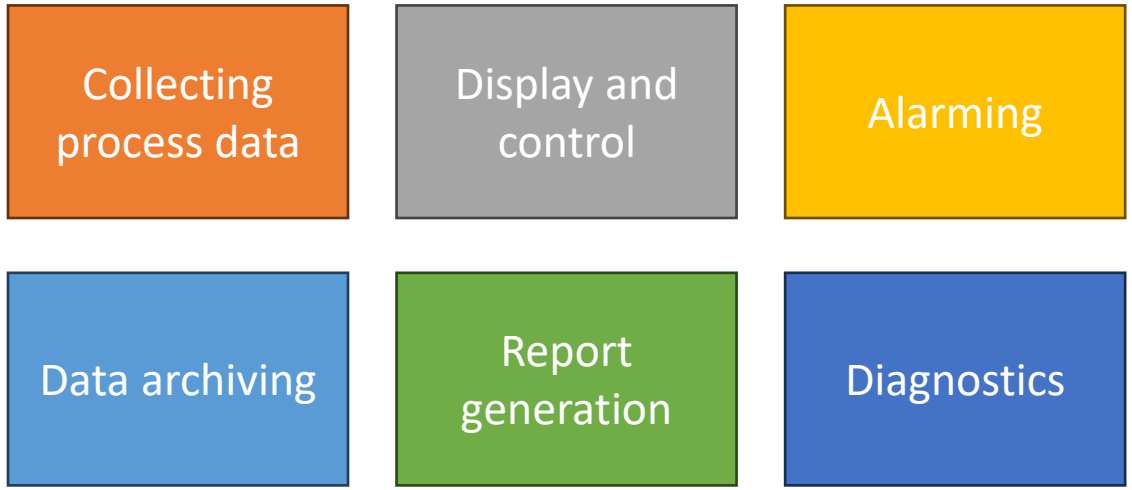
Various manufacturers

- Process equipment manufacturers
  - RSView (Rockwell)
  - LabView (National Instruments)
  - WinCC (Siemens)
  - TwinCAT HMI (Beckhoff)
- Independent manufacturers
  - FactoryLink (USData - UGS)
  - InTouch (Wonderware)
  - iFIX (Intellution – GE Fanuc)
- Open-source projects
  - OpenSCADA (http://oscada.org)
  - OpenAPC (https://www.openapc.com)
  - ScadaBR (https://github.com/ScadaBR)
  - IndigoSCADA (http://www.enscada.com/a7khg9/IndigoSCADA.html)

# Overview

Functions provided by software tools:

- Collecting process data
- Display and control
- Alarming
- Data archiving
- Report generation
- Diagnostics

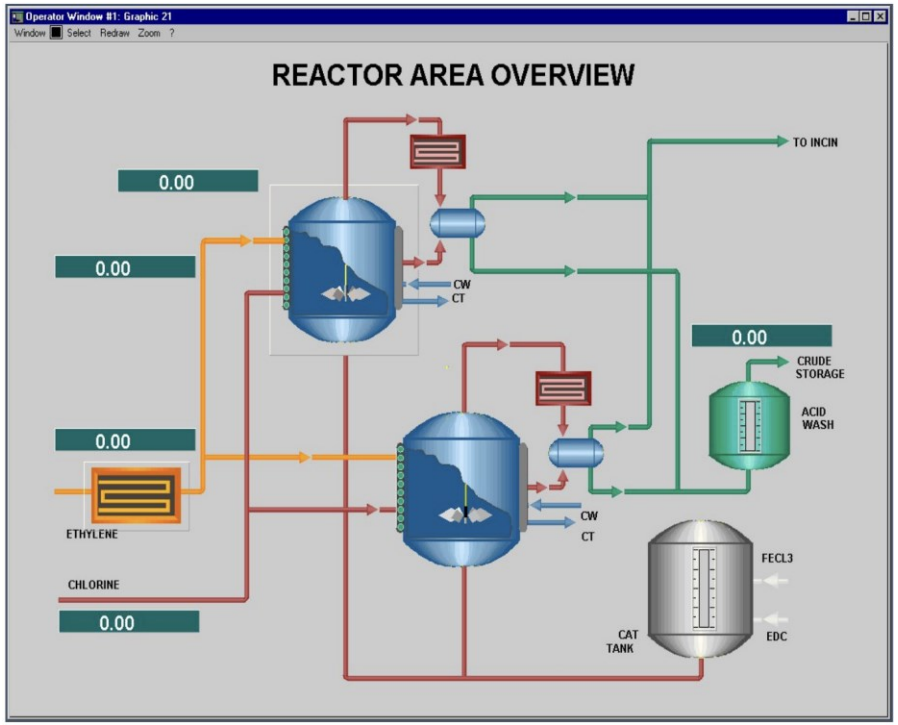


# Collecting Process Data

- Based on a certain event or at a pre-determined time.
- The speed of handling process data depends on the process.
- We need interfaces and drivers to access process data:
  - Controllers, regulators, etc.
  - Standard ones are already available in software packages, specific ones need to be acquired from manufacturers.
- Elements of the data structure are called tags:
  - A tag represents a single input or output value in the system.
  - There can be from a few hundred to several thousand tags (ranging from a few 100 to around 10,000 points).

# Displays and Control

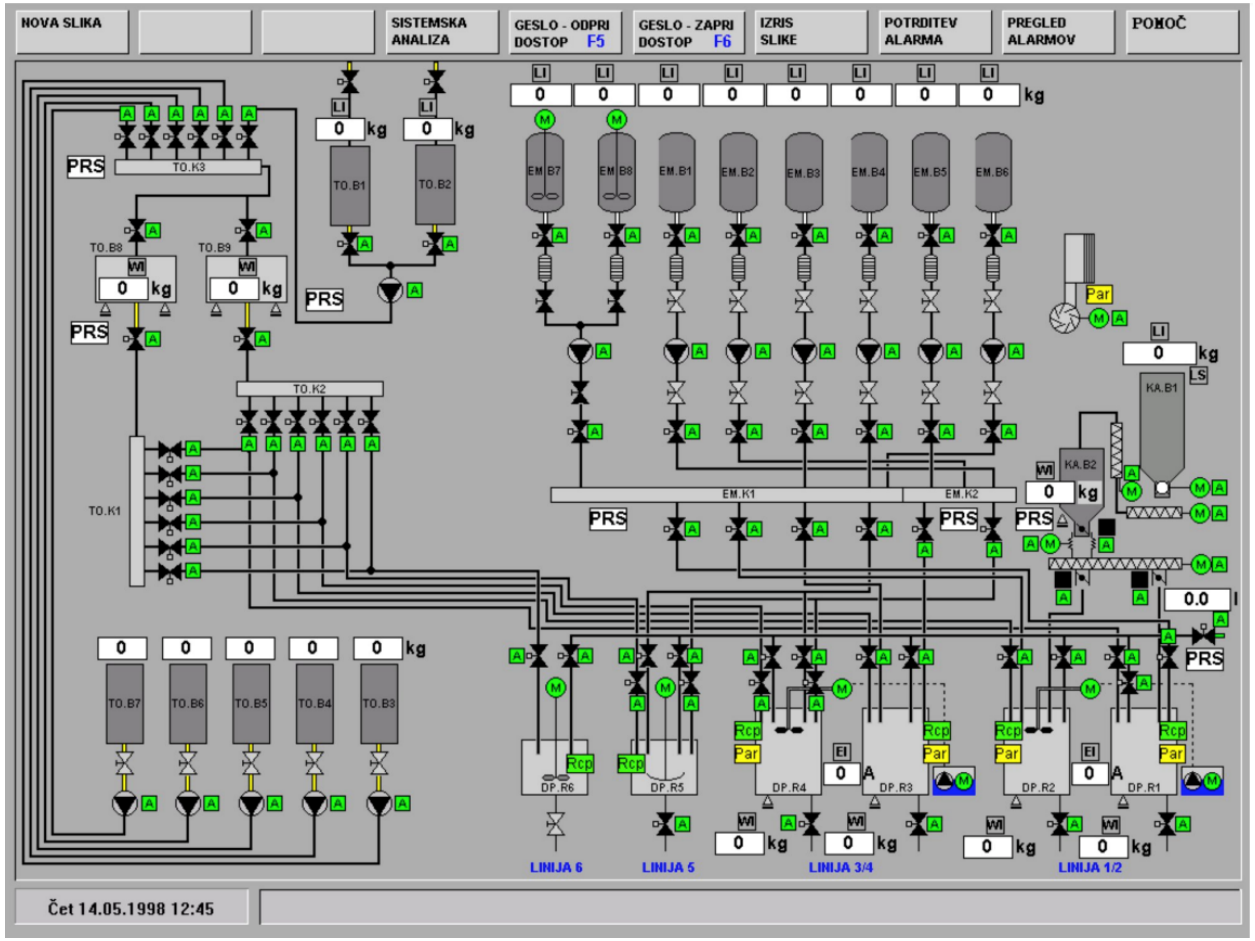
- The operator has the ability to view and intervene in the process operation.
- Interaction must be simple and understandable:
  - Typically, a process diagram is prepared for the system we are controlling.
  - Simple graphical elements: shapes, diagrams, photos, etc.
  - Less is more.
- Data can be displayed in various ways:
  - Textual displays
  - Graphical displays:
    - Simple displays: traffic lights (valve open/closed)
    - Complex: animations, colors (e.g., position of an elevator in a skyscraper)
- Access limitations and possibilities for intervention in the process (user accounts, permissions)
- Recipes



# Displays and Control

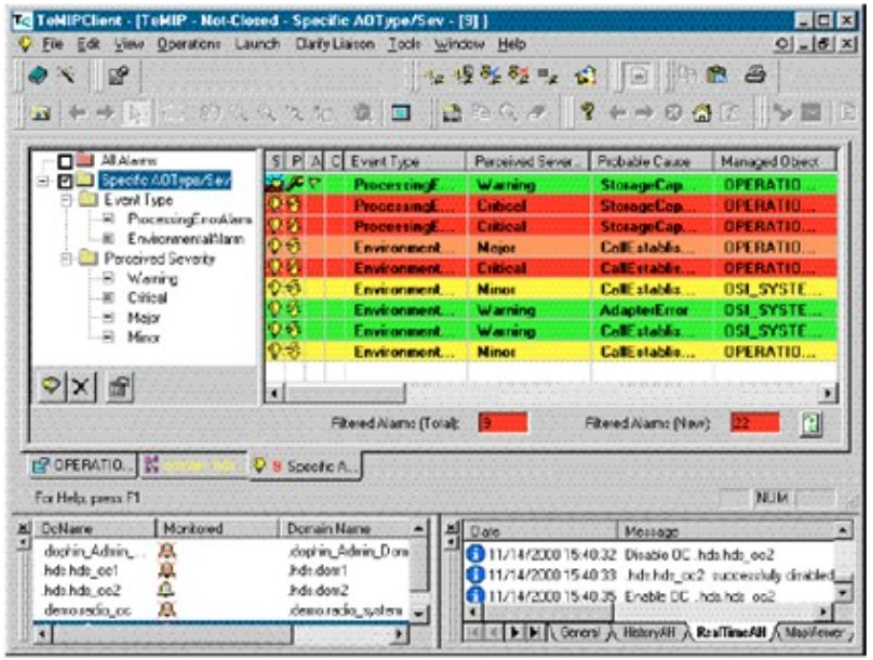
Example: Pump

- Display of flow (analog or digital)
- Display of any errors (color signals)
- The operator can turn off the pump via the keyboard/mouse – immediately visible on the screen as the flow decreases.



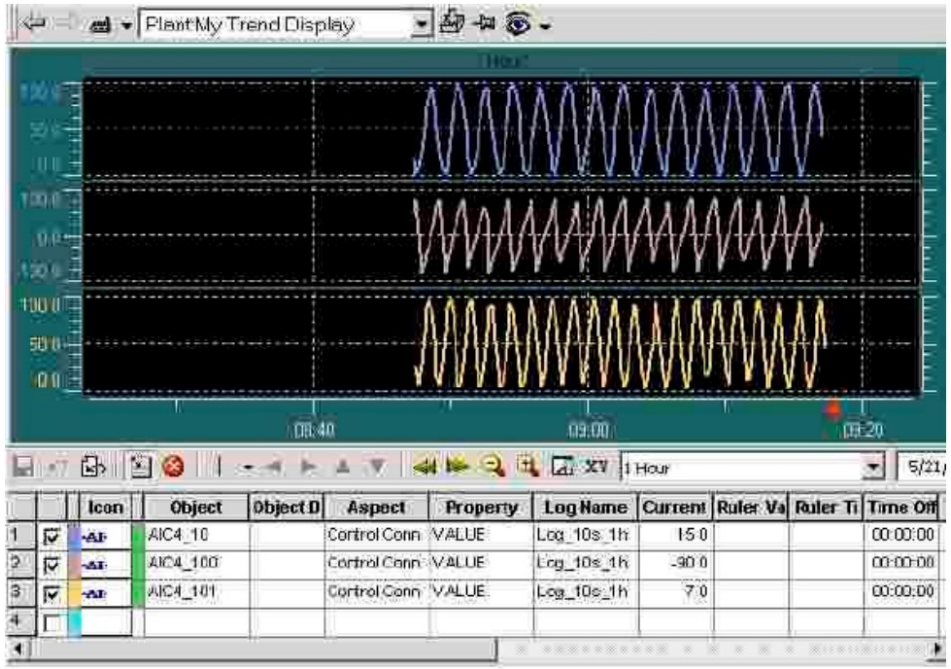
# Alarms

- An important function of supervisory systems is to notify in case of deviations from the allowed value range.
- Alarms attract the operator's attention – requiring quick action.
- Managing Alarms
  - Defining a list of alarms
  - And conditions for their triggering.
  - Confirming alarms: Individually or all at once?
- Alarms can be grouped together, given priorities, and color-coded when displayed.
- Notifications
  - Display notification, siren, SMS, email, etc.



# Archiving and Report Generation

- Data Archiving
  - Data is stored in files or databases (SQL, MS Access, etc.).
  - SCADA systems typically use distributed databases.
- Report Generation
  - Creation of various prints and reports based on current and archived process data.
- Additional
  - Increasing analysis of data, statistics, and special analyses stemming from technology.

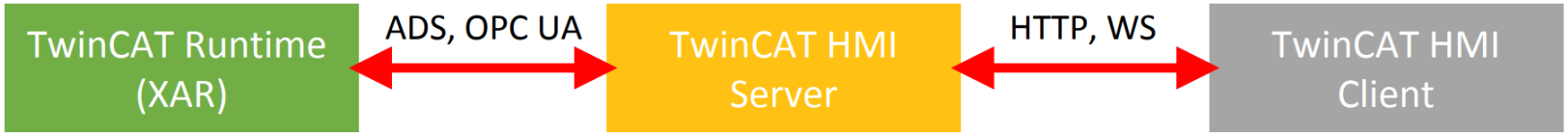


# Tools

- Development and Execution Environment
  - Modularity in larger systems
  - Integration and connectivity
- Development Environment
  - Object-oriented approach
  - Setting properties for objects, connecting to tags (points)
  - Support for security (authorizations)
  - Scripts
  - Multilingual support

# TwinCAT HMI

- **Technology**
  - Modern ecosystem for the web (HTML5, CSS3, JavaScript, TypeScript)
  - Platform independence, responsive design
- **Architecture**
  - TwinCAT Runtime (XAR) communicates via ADS, OPC UA with TwinCAT HMI Server
  - TwinCAT HMI Server communicates via HTTP, WS (WebSocket) with TwinCAT HMI Client




- **Functionalities** (official demo)
  - Basic elements (buttons, input fields, tables, graphs, icons, etc.)
  - Alarms, events, diagnostics
  - Recipes
  - Past events, trends
  - User account monitoring
  - Multilingual support

[Video tutorials]

[Beckhoff Infosys]