

A SCADA web application using OpenACS and topcua, running on a single-board computer

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Some Tci-relevant facts about me (1/3)

- 1984
 - L'Elettrotecnica is founded in Mantua by my father Aldo Pisano. The company provides components, consultancy and bespoke development for industrial automation.
- 1985
 - I am born in Mantua.



Some Tcl-relevant facts about me (2/3)

- 2009
 - I obtain my bachelor degree in computer science.
- 2010
 - L'Elettrotecnica adopts Alter, an ERP based on OpenACS and developed by Oasi Software After a few contributions as a customer, I start collaborating with Oasi Software on ERPs for the private sector, where I meet and learn from Claudio Pasolini and Maurizio Martignano.
- 2012
 - I leave Oasi Software to go back to my studies. I also keep maintaining and extending the Alter ERP for L'Elettrotecnica as a fork.

Some Tcl-relevant facts about me (3/3)

- 2013
 - I become official member of L'Elettrotecnica S.r.l., I am also accepted as an official OpenACS contributor.
- 2015
 - I obtain my Master degree in computer science and go back working for Oasi Software, this time mostly on systems for the public sector.
- 2016
 - I accept a job as System Manager for LEARN at the Vienna University for Economics and business, supervised by Prof. Gustaf Neumann.

What I do now

- Today, most of my coding goes to LEARN and upstream OpenACS here in Vienna.
- I still maintain the Alter ERP for L'Elettrotecnica, both in a support and development capacity
- I am sometimes involved in projects for L'Elettrotecnica where some more "Generic IT" is required
- This is one of those projects :-)

Case study (1/2)

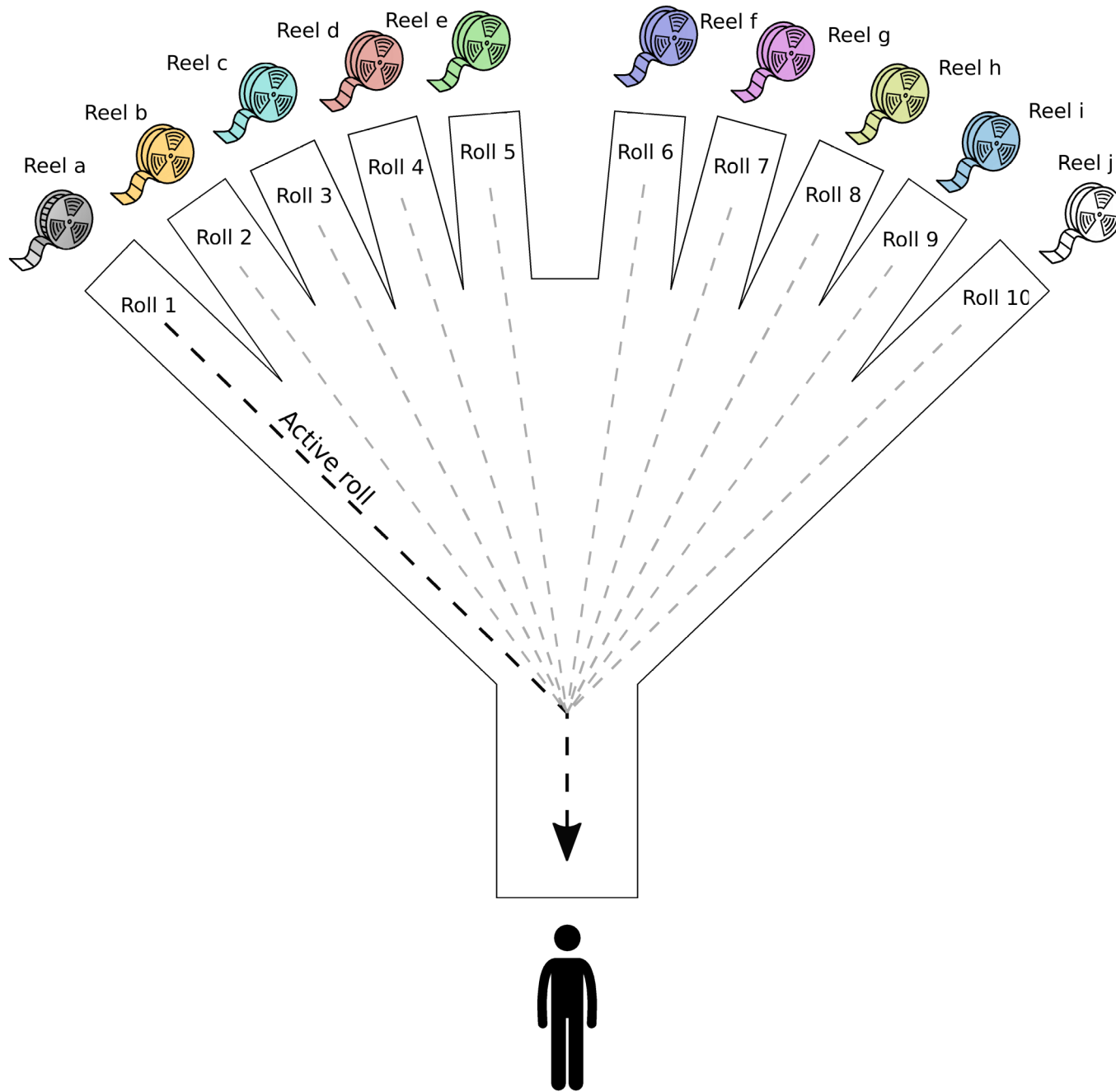
- An established business specialized in the manufacturing of construction glass.
- Among the tasks carried out during glass manufacturing is the processing of special **plastic materials** in order to give glass a distinct color and mechanical properties.



Case study (2/2)

- Materials are purchased and handled in **reels**. Each reel of material has different properties: type of resin, color, width, thickness, length...
- The machine used to process the plastic material has **10 rolls**, each loaded with at most one reel of material.
- Only one of the 10 rolls is processed at any given time, the **active roll**.





Existing system - Components

- **Control PLC** – PLC responsible of controlling the actual plant, e.g. dispense the material and operate the rolls
- **Measurement PLC** – PLC measuring the length of material dispensed during the processing session and the length of remaining material on the active roll.
- **HMI** – Runs the User interface and stores the list of available reels and their assignment to a roll. It runs an integrated **OPC-UA** server.
- The components together constitute a small **SCADA** system

PLC – What is it

- Programmable Logic Controller, invented in 1968 by Richard Morley
- A computer optimized for reliability and real-time applications in industrial setups
- Can range from tens to thousands of integrated IO ports



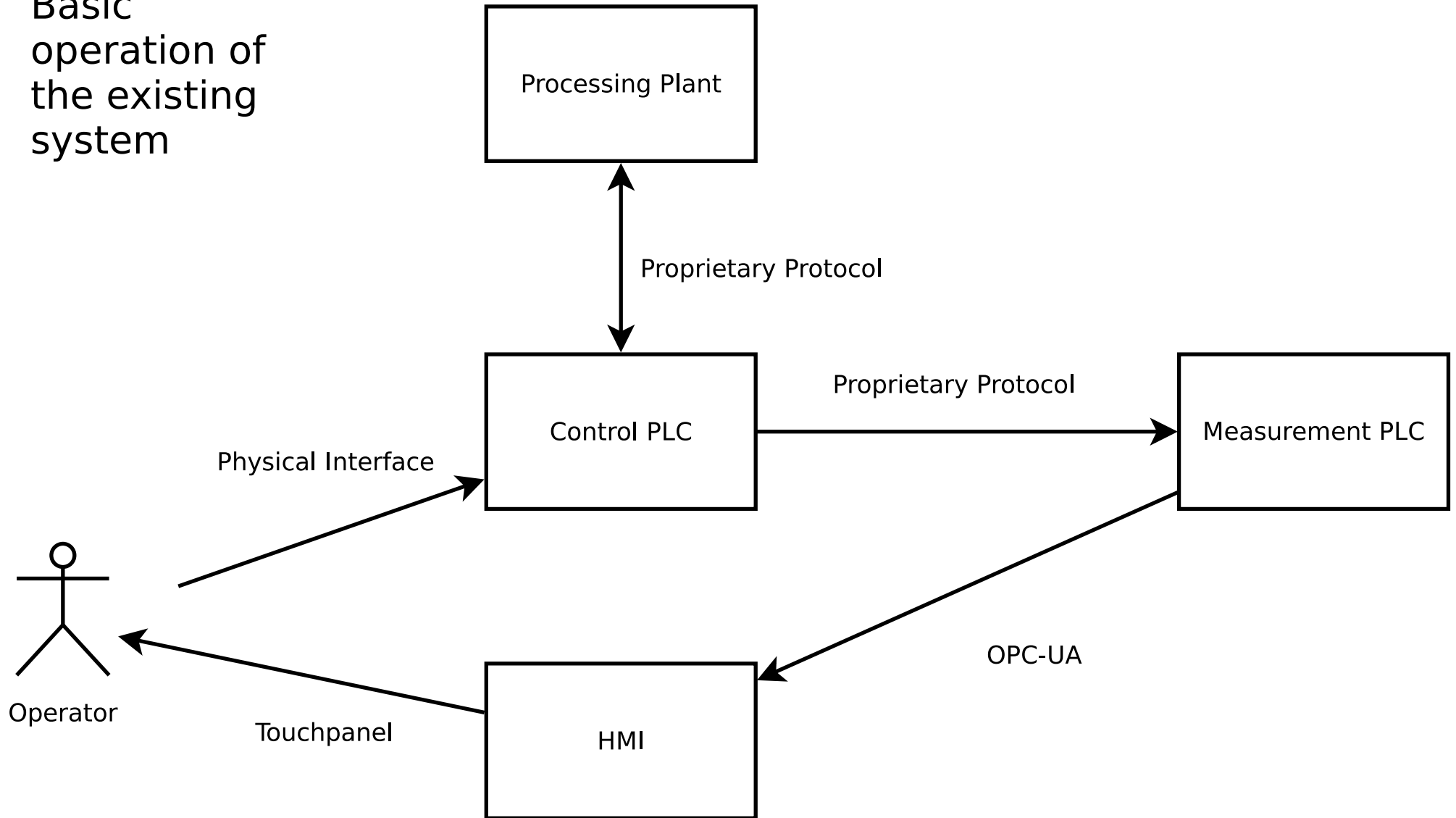
OPC-UA – What is it

- OPC Unified Architecture, successor of the original Open Platform Communication Protocol
- Maintained by the OPC foundation, founded by many key players in the industry
- Does not depend on Windows like its predecessor
- A series of standards and specifications for industrial telecommunication
- Allows interoperability between industrial components from different manufacturers and other systems such as SCADAs and ERPs

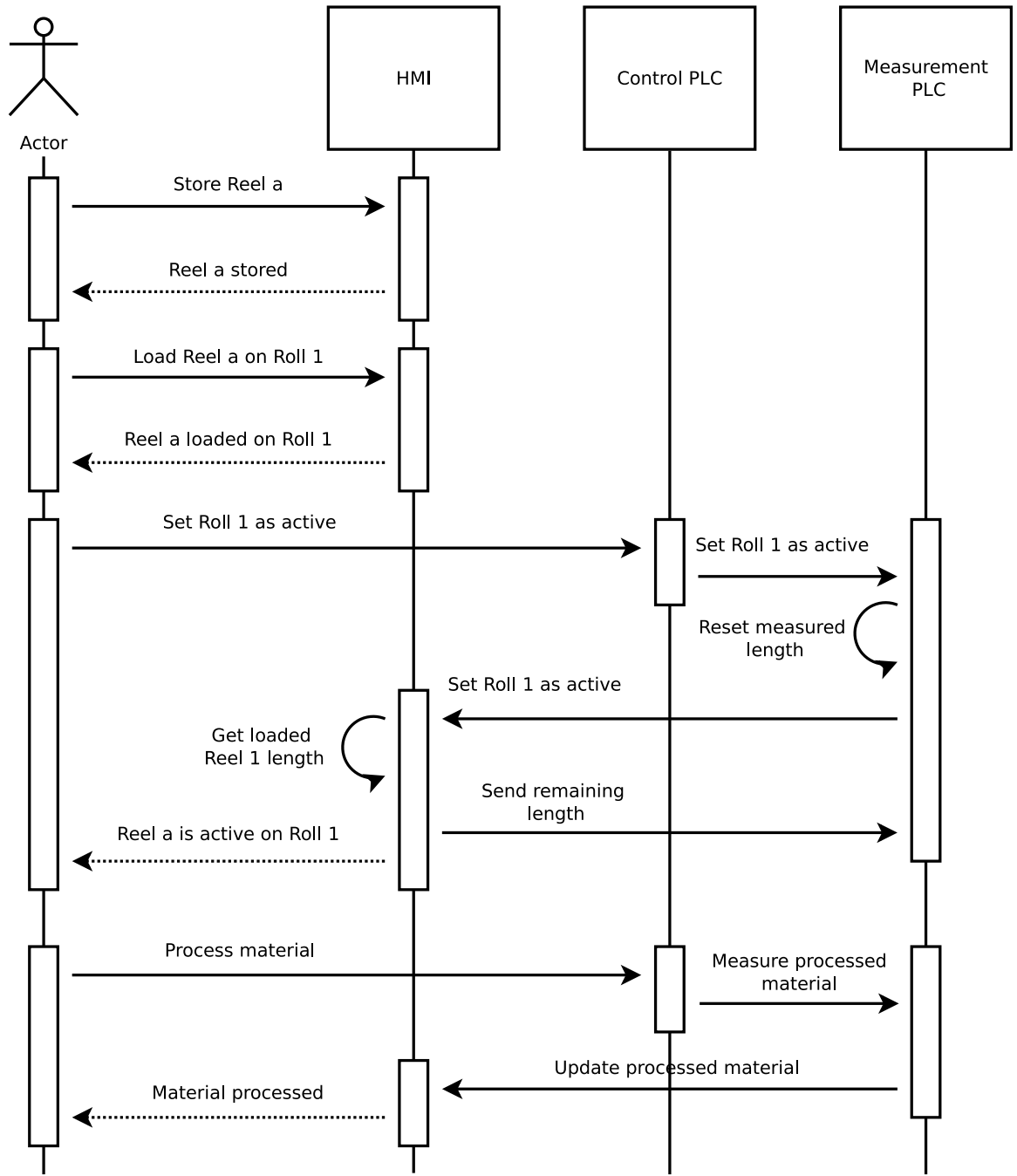
SCADA – What is it

- A system capable of supervising a variety of other proprietary devices.
- Typically consists of PLCs or Remote Terminal Units connected to sensors and actuators, communicating with a supervisory computer via a protocol, such as OPC-UA.
- The user can control the setup via a Human Machine Interface, which sometimes is embedded in the supervisory computer.

Basic
operation of
the existing
system



Sequence diagram of the existing system



New functional requirements

- Keep an accurate long term history of material consumption
 - HMI can only store currently available reels
 - HMI has a limited amount of persistent memory
 - Consumption is reported manually by the operator
- List of available reels should be managed directly by the Purchase Office
 - Reels available for processing must be inserted manually in the HMI by the operator
- The UI should remain familiar for operators in the plant
 - Operators are used to interact with the HMI panel

From functional to technical requirements

- “Big” long-term storage
- Possibility to structure information in a data model → DBMS
- Some form of access control
- Viewable on the HMI → VNC or web based
- Access to data from existing system → OPC-UA capable
- Good reliability
- Small form factor

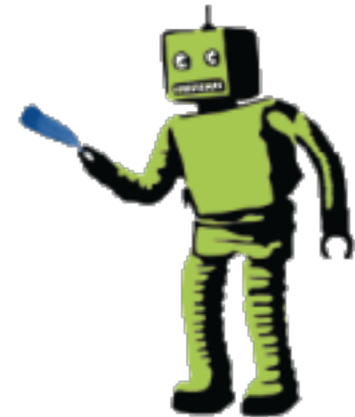
New system components - OpenACS

- Web-based
- Scalable up AND down
- Built-in access control
- Postgres DBMS



New system components - topcua

- Tcl binding to the OPC-UA implementation of open62541
- open62541 is a reliable OPC-UA implementation endorsed by the OPC Foundation
- topcua is part of AndroWish by our own Christian Werner :-)

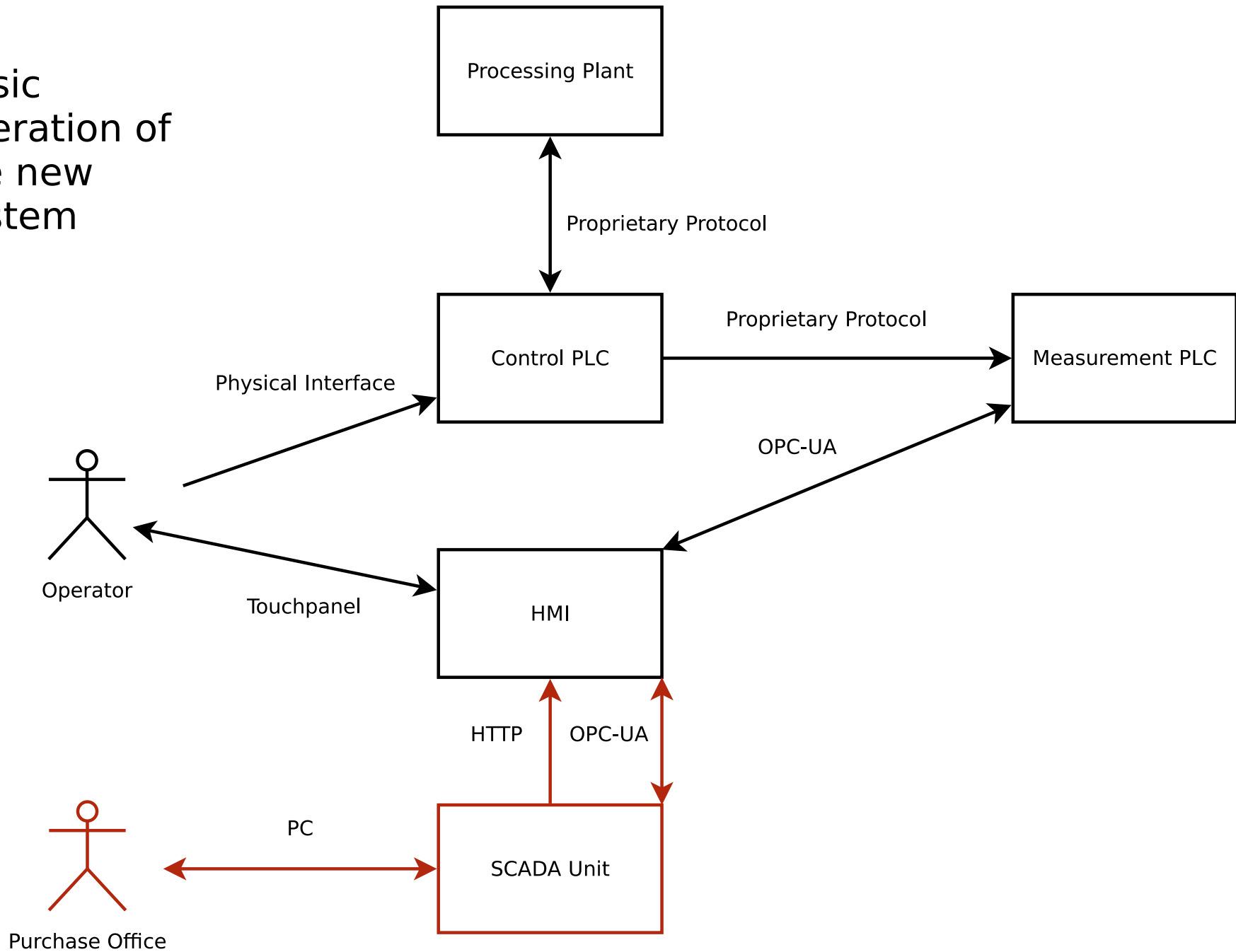


New system components - OLinuXino A64

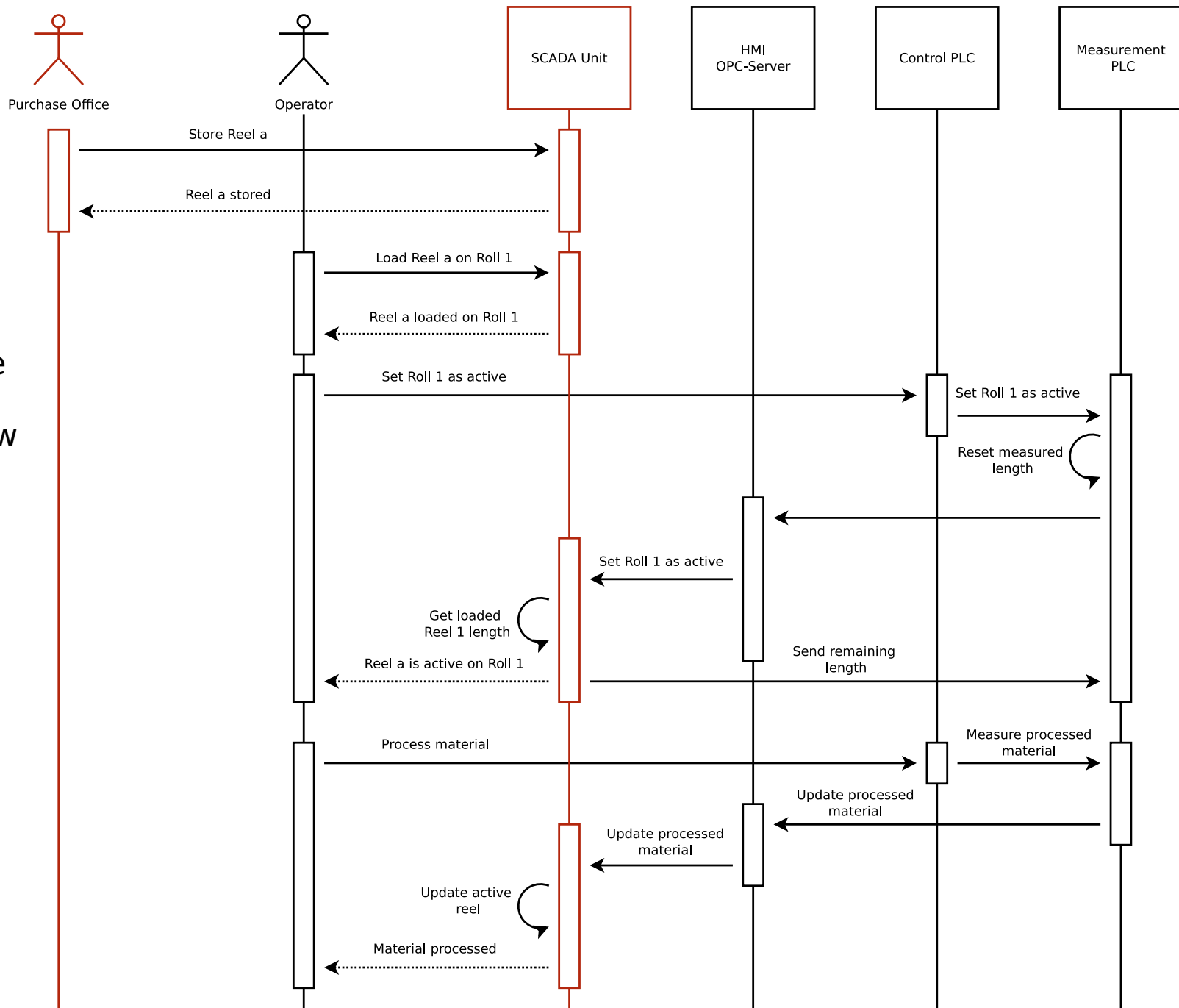
- Small and fan-less
- Works in the industrial -40+85C temperature range
- Open source software AND hardware
- 1.2 GHz Quad-Core ARM Cortex-A53 64-bit
- 2GB RAM DDR3L @ 672Mhz
- 8GB eMMC flash memory + SD card slot for storage



Basic operation of the new system



Sequence diagram of the new system



Notes on the new system

- Operators keep interacting with the HMI touch-panel, however, the UI is now hosted on the SCADA Unit
- The SCADA Unit will also produce a daily report of the currently available materials in csv format, exported via network share
- In a sense, the SCADA Unit is both a supervisory computer and a small ERP

SCADA Unit – Some details (1/5)

- At startup, the unit subscribes with a number of OPC variables published by the HMI/OPC-Server, stored in a configuration file
- The HMI requires a trivial self-signed certificate in order to communicate
- The OPC update interval is set to 500ms

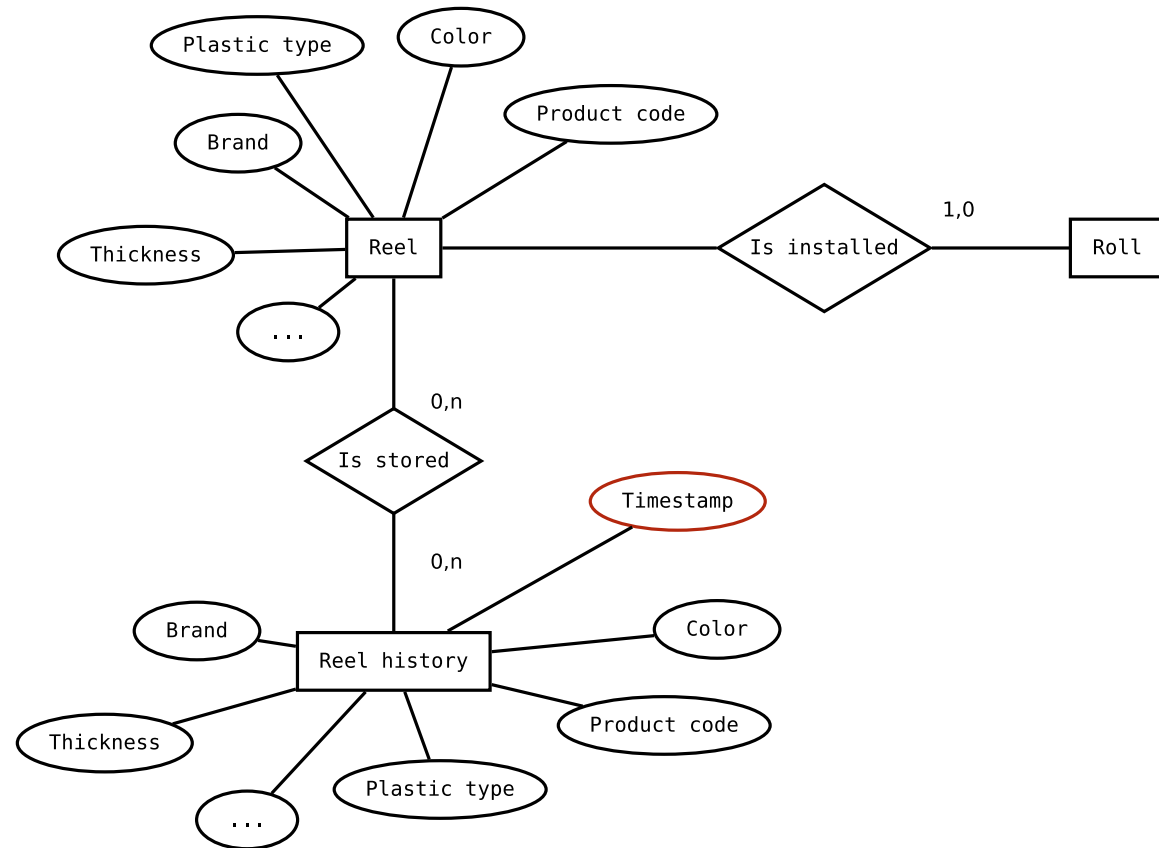
```
"url": "opc.tcp://192.168.31.156:4840/",
"interval": 500,
"client_cert": "/var/www/oacs-5-10/packages/opc/certs/client_cert.der",
"client_key": "/var/www/oacs-5-10/packages/opc/certs/client_key.der",
"nodes": [
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.N.RULLO IN USO",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.PRESENZA FILM IN EROGAZIONE",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.LUNGHEZZA MM EROGATI",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 1 FINE EROGAZIONE",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 1 LUNGHEZZA M RIMANENTI AL PLC",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 1 LUNGHEZZA M RIMANENTI DAL PLC",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 1 ROTOLO IN ESAURIMENTO",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 1 CAMBIO NON CONSENTITO",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 2 FINE EROGAZIONE",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 2 LUNGHEZZA M RIMANENTI AL PLC",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 2 LUNGHEZZA M RIMANENTI DAL PLC",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 2 ROTOLO IN ESAURIMENTO",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 2 CAMBIO NON CONSENTITO",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 3 FINE EROGAZIONE",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 3 LUNGHEZZA M RIMANENTI AL PLC",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 3 LUNGHEZZA M RIMANENTI DAL PLC",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 3 ROTOLO IN ESAURIMENTO",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 3 CAMBIO NON CONSENTITO",
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  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 4 LUNGHEZZA M RIMANENTI AL PLC",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 4 LUNGHEZZA M RIMANENTI DAL PLC",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 4 ROTOLO IN ESAURIMENTO",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 4 CAMBIO NON CONSENTITO",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 5 FINE EROGAZIONE",
  "ns=2;s=FATEK FB/FBs/B1/B1z Series.Tags.RULLO 5 LUNGHEZZA M RIMANENTI AL PLC"
```


SCADA Unit – Some details (2/5)

- Continuous checks and error handling are in place to make the unit resilient to temporary loss of connection or unexpected restarts, which may occur in a productive environment.
- A callback is registered for every variable subscription in order to react to changes. The actual reaction depends on the status of specific flags in the PLC:
 - Save current quantity of consumed material
 - Notify material depletion
 - Switch the active roll
 - ...

SCADA Unit - Some details (3/5)

- A simple datamodel was created to store the data



SCADA Unit – Some details (4/5)

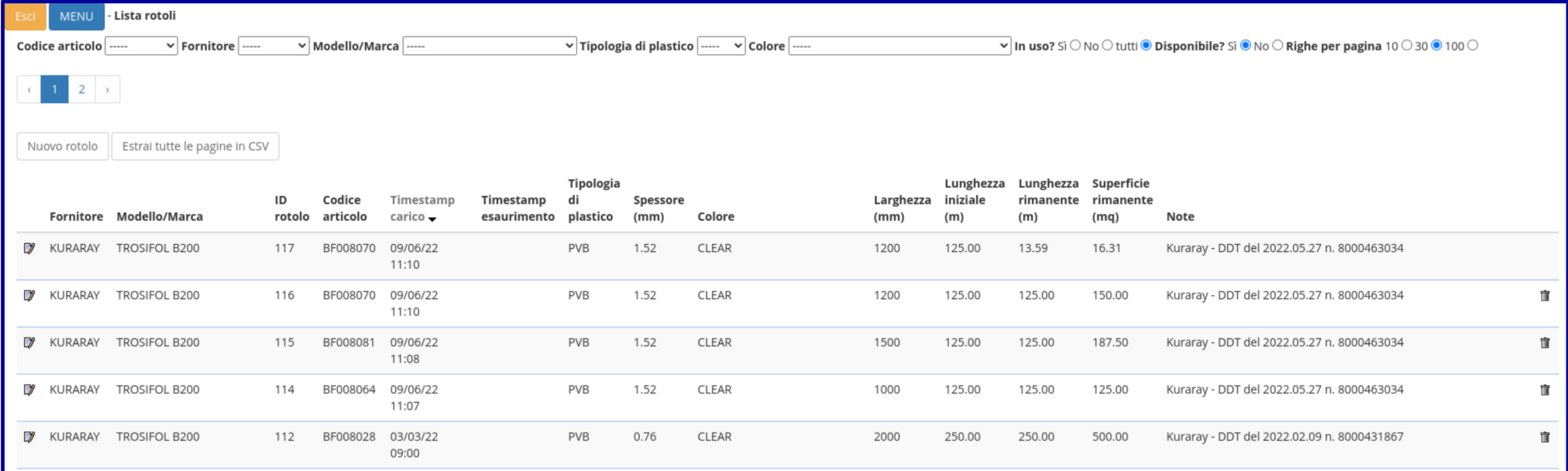
- Interfaces shown on the HMI are optimized for a 7” display and high legibility

The screenshot displays a SCADA HMI interface for 'Rullo attivo 6'. The interface is organized into three main sections: a left column for data entry, a central column for status indicators, and a right column for monitoring data.

Field Name	Value	Status/Action	Monitoring Data
FORNITORE	KURARAY	PRESENZA FILM IN EROGAZIONE	LUNGHEZZA EROGATA (MM) 0
MODELLO/MARCA	TROSIFOL B200	FINE EROGAZIONE	LUNGHEZZA RIMANENTE (M) 96.10797882080078
ID ROTOLO	63	ROTOLO IN ESAURIMENTO	SUPERFICIE RIMANENTE (MQ) 147.05
TIPOLOGIA DI PLASTICO	PVB	CONFERMA ELIMINAZIONE ROTOLO ESAURITO	
SPESSORE (MM)	0,38		
LARGHEZZA (MM)	1530		
COLORE	CLEAR		
CODICE ARTICOLO	BF008082		
TIMESTAMP CARICO	07/09/21 15:38		
LUNGHEZZA INIZIALE (M)	400.00		

SCADA Unit – Some details (5/5)

- A custom Bootstrap-based OpenACS theme based on the upstream theme by Monika Andergassen has been created to keep look and feel responsive and consistent also on other interfaces and apply local customizations



The screenshot shows a web application interface for managing rollers. At the top, there is a navigation bar with 'Esci' and 'MENU' buttons, and a title '- Lista rotoli'. Below the navigation bar, there are several filter dropdown menus: 'Codice articolo', 'Fornitore', 'Modello/Marca', 'Tipologia di plastico', and 'Colore'. To the right of these filters, there are radio buttons for 'In uso?' (Si, No, tutti) and 'Disponibile?' (Si, No), and a 'Righe per pagina' selector (10, 30, 100). Below the filters, there are two buttons: 'Nuovo rotolo' and 'Estrai tutte le pagine in CSV'. The main content area is a table with the following columns: 'Fornitore', 'Modello/Marca', 'ID rotolo', 'Codice articolo', 'Timestamp carico', 'Timestamp esaurimento', 'Tipologia di plastico', 'Spessore (mm)', 'Colore', 'Larghezza (mm)', 'Lunghezza iniziale (m)', 'Lunghezza rimanente (m)', 'Superficie rimanente (mq)', and 'Note'. The table contains five rows of data, each representing a roller with its specific characteristics and status.

Fornitore	Modello/Marca	ID rotolo	Codice articolo	Timestamp carico	Timestamp esaurimento	Tipologia di plastico	Spessore (mm)	Colore	Larghezza (mm)	Lunghezza iniziale (m)	Lunghezza rimanente (m)	Superficie rimanente (mq)	Note
KURARAY	TROSIFOL B200	117	BF008070	09/06/22 11:10		PVB	1.52	CLEAR	1200	125.00	13.59	16.31	Kuraray - DDT del 2022.05.27 n. 8000463034
KURARAY	TROSIFOL B200	116	BF008070	09/06/22 11:10		PVB	1.52	CLEAR	1200	125.00	125.00	150.00	Kuraray - DDT del 2022.05.27 n. 8000463034
KURARAY	TROSIFOL B200	115	BF008081	09/06/22 11:08		PVB	1.52	CLEAR	1500	125.00	125.00	187.50	Kuraray - DDT del 2022.05.27 n. 8000463034
KURARAY	TROSIFOL B200	114	BF008064	09/06/22 11:07		PVB	1.52	CLEAR	1000	125.00	125.00	125.00	Kuraray - DDT del 2022.05.27 n. 8000463034
KURARAY	TROSIFOL B200	112	BF008028	03/03/22 09:00		PVB	0.76	CLEAR	2000	250.00	250.00	500.00	Kuraray - DDT del 2022.02.09 n. 8000431867

Challenges

- A couple of small bugs in topcua had to be sorted out, but Christian was very reactive and helpful
- HMI browser component sensitive to reloads
- No websockets in the HMI browser
- Some requirements became clear only along the way
- ...all development happened remotely. In fact, I have never seen the actual plant!

Special thanks

- Christian Werner for implementing topcua and providing solicit support during this project
- Stefano Piccinini, in-house technician at L'Elettrotecnica, for providing his expertise and support on the field

Thanks for watching!

- My contacts
 - antonio@elettrotecnica.it
 - <https://github.com/Elettrotecnica>
- Links to the tools in this talk
 - <https://openacs.org/>
 - <https://www.androwish.org/index.html/wiki?name=topcua>
 - <https://www.olimex.com/Products/OLinuxino/A64/A64-OLinuxino/>