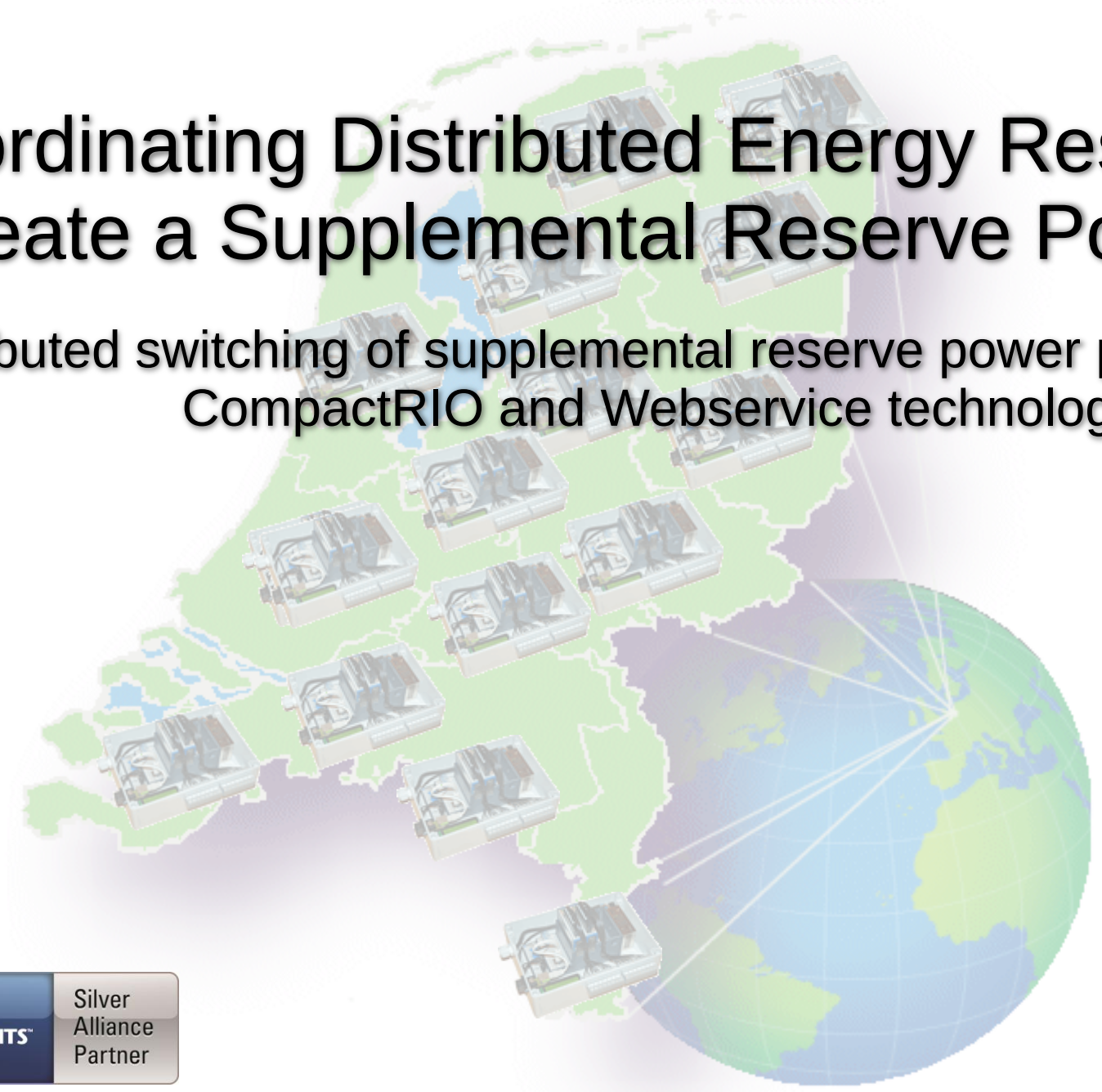
VIT echnologies

Coordinating Distributed Energy Resources to Create a Supplemental Reserve Power Grid

Distributed switching of supplemental reserve power pools based on CompactRIO and Webservice technology



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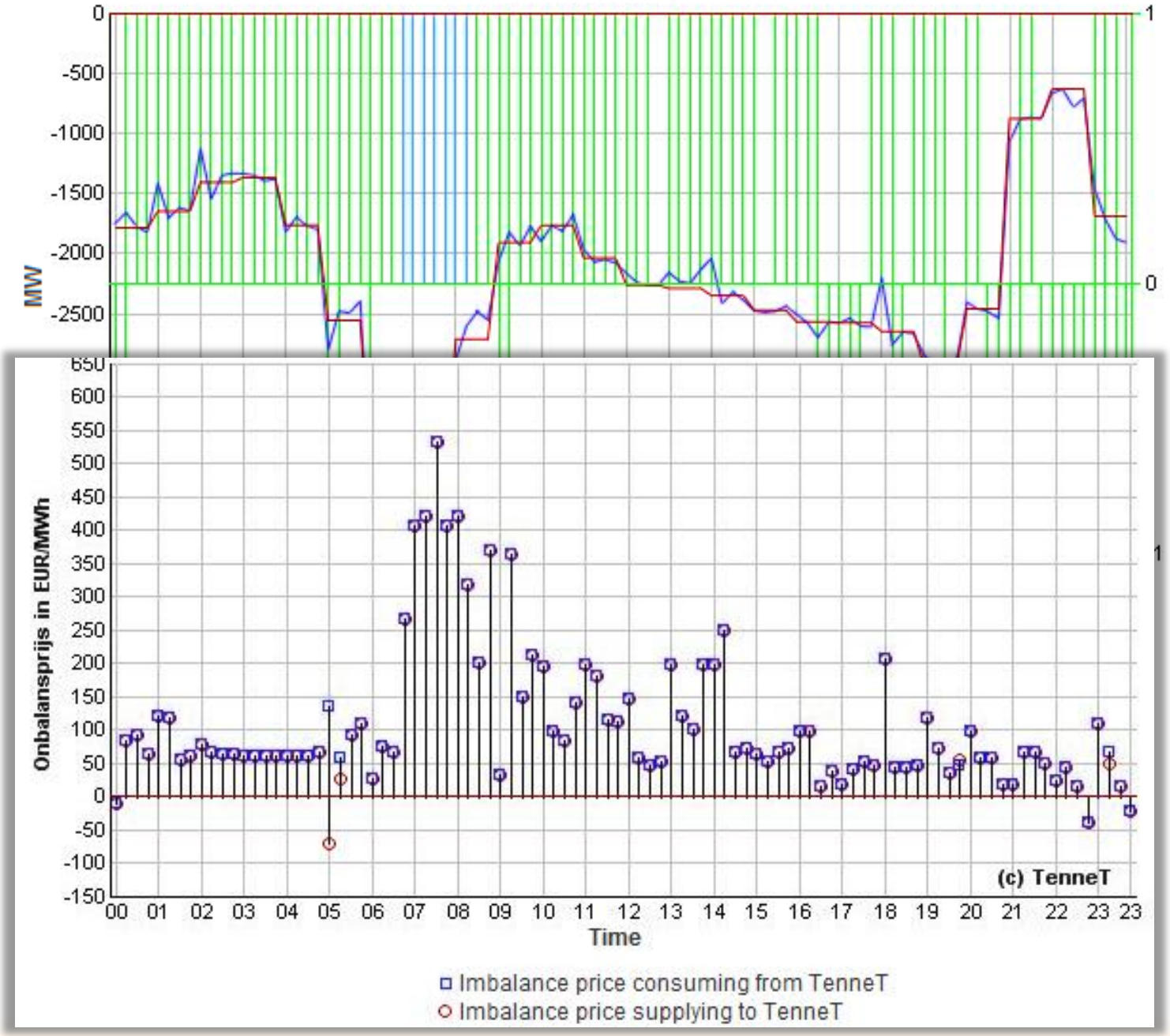
Agenda

- Keeping the grid balanced
- Supplemental reserves in a pool
- System requirements
- System setup
- Web Services
- System overview
- UI Impressions
- Lessons learned

Keeping the grid balanced

- Maintainer of Dutch powergrid TenneT has a task to keep the grid balanced
- Adjust the balance using regulating or supplemental reserves
- Regulating reserves
  - Continuously adjustable in steps of 1MW
  - Response time 30 sec
  - Regulating speed min. 7% per min.
- Supplemental reserves
  - 20-25 MW switchable power, availability > 97%
  - Response time max. 15 min.

Keeping the grid balanced



Supplemental reserves in a pool

- Only larger industries and e.g. horticulture (greenhouses) are eligible for the 20MW contracts
- The market for supplemental reserves gets significantly larger by involving smaller players
- By combining several smaller parties (0,5 – 5MW) in a pool we can comply with the contractual requirements of at least 20MW
- When talking of smaller parties, think for example hospitals and datacenters
- Annual compensation ~ € 600k / 20MW stand-by

Supplemental reserves in a pool

- The pool maintainer (NL Noodvermogenpool) has the 20MW contract with TenneT
- NL Noodvermogenpool contracts the smaller parties that will be part of the supplemental reserves pool
- The pool coordination system we built is facilitated by our customer Anode Energie

NL Noodvermogenpool

www.nlnvp.nl

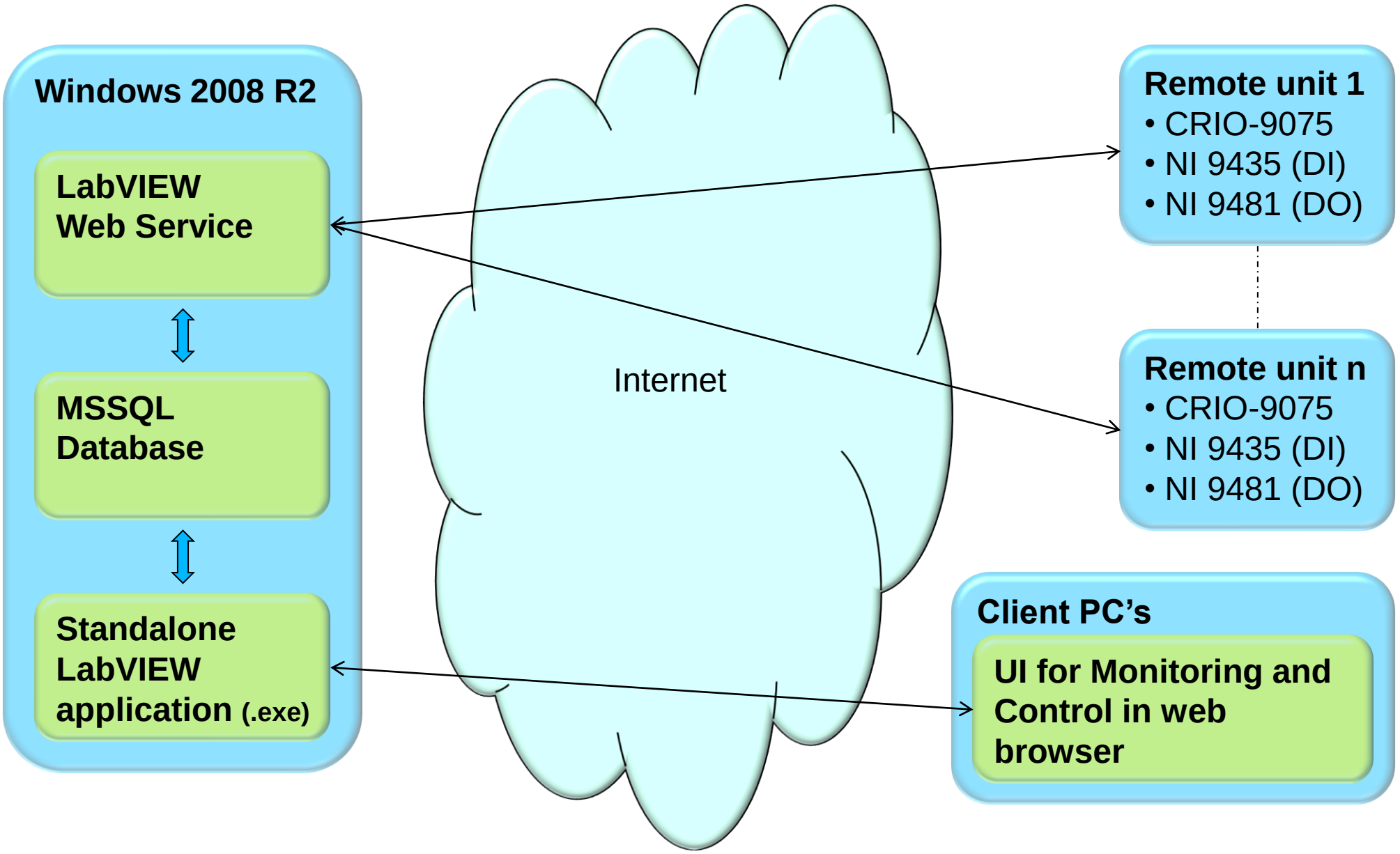
ANODE Energie

www.anode.nl

System requirements

- 30 remote switch units for control and monitoring of 1 or 2 emergency generators
- Units connect to server via the Internet and should be able to operate from behind firewall
- Units are relatively ‘dumb', most business logic on server
- Ability to perform remote-update of firmware
- Log everything that happens in the system
- Server UI supports control and monitor of individual units or entire groups (clusters) of units at once
- SMS and E-mail notification if a unit goes offline or when there’s a call for reserve power
- Go live in less than 4 months...

System setup

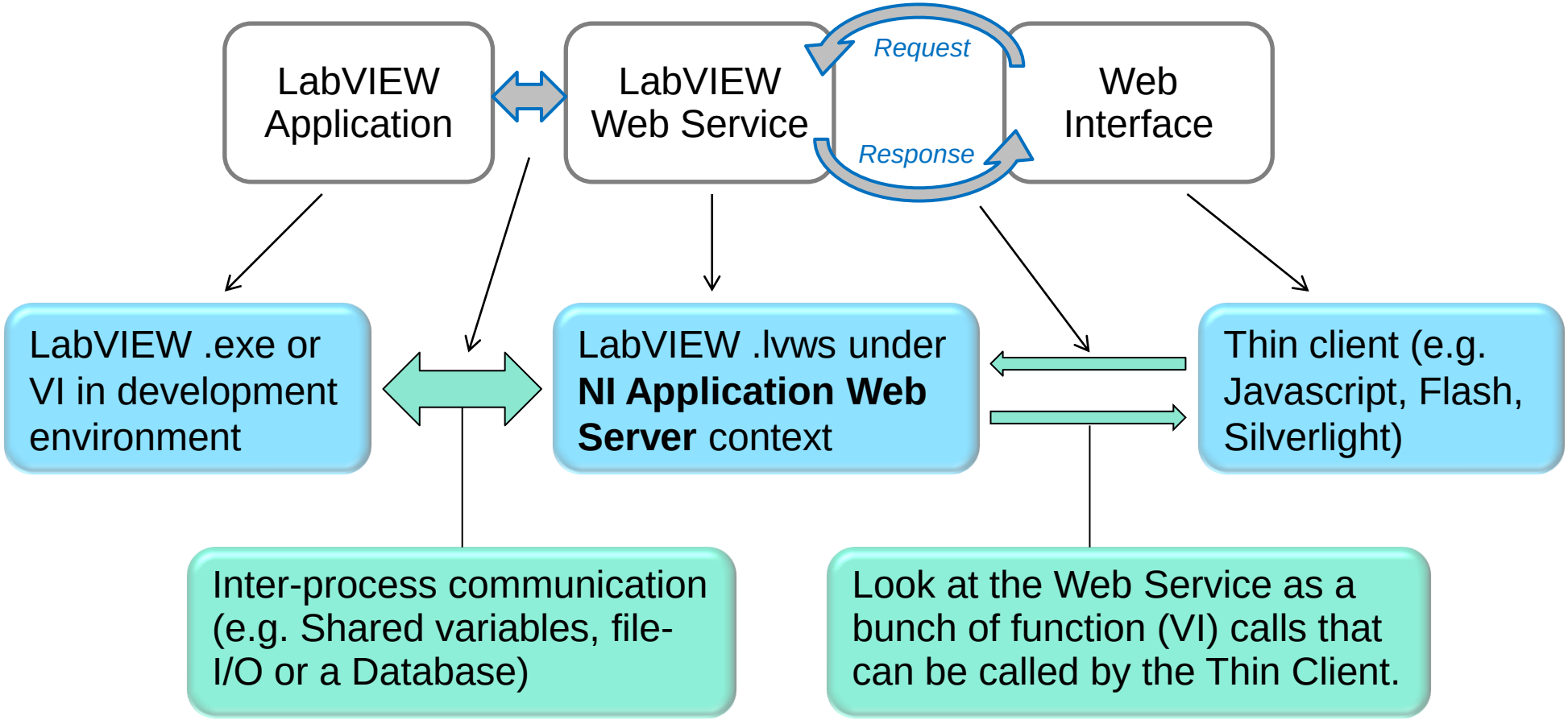


Web Services

Why web services?

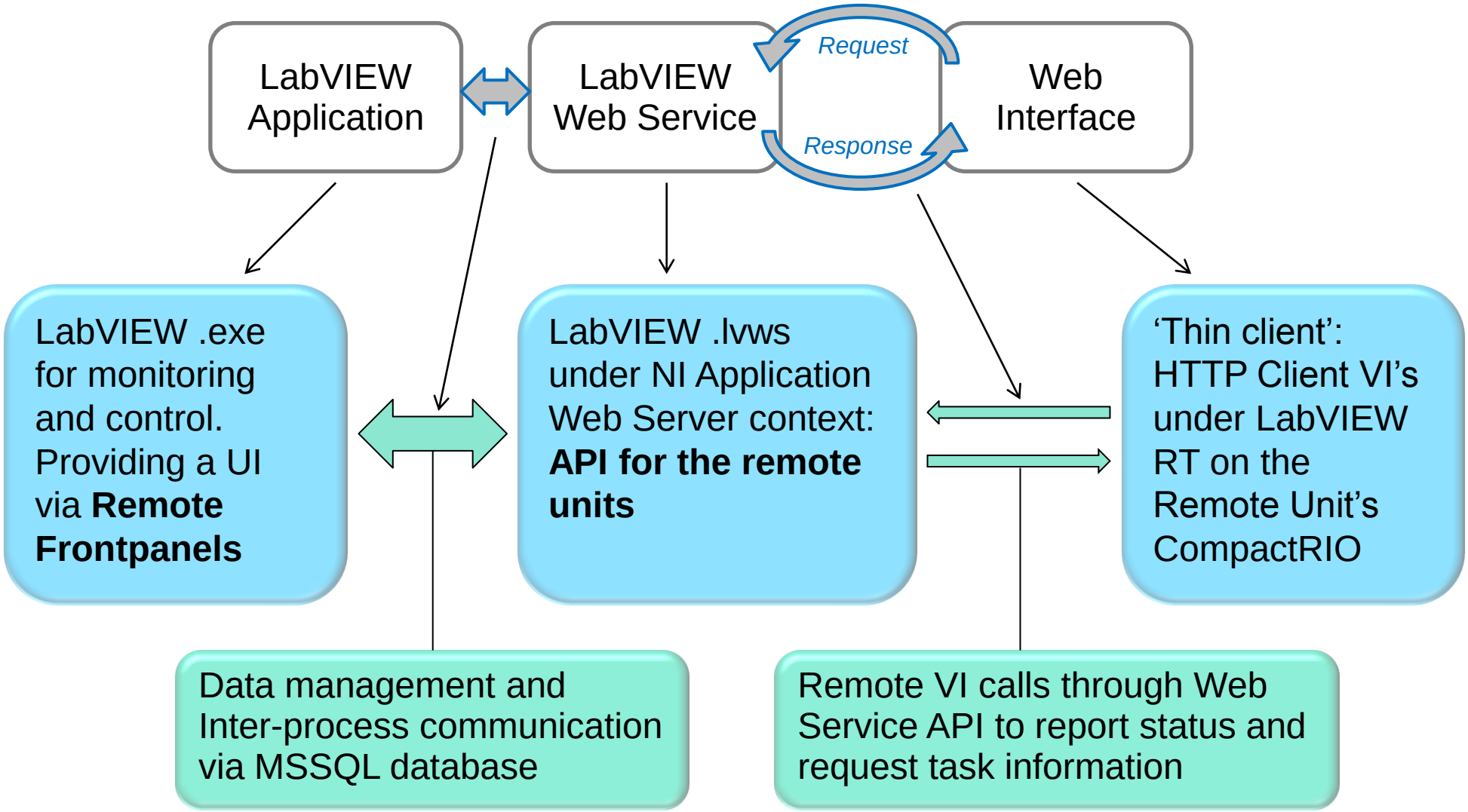
Req: “Units connect to server via the Internet and should be able to operate from behind firewall”

Standard http(s) traffic, no problem for most firewalls



Web Services

So how does that map to our use-case?



1. TenneT needs supplemental reserve power.
2. Tennet operator calls the call centre.
3. Callcentre operator opens the remote panel
4. Operator 'pushes the button' and confirms.
5. LabVIEW Server Application creates task in database for units in the pool.
6. Within 10 seconds, all applicable units will have picked up the switch task.
7. Units report their switched status and feedback from the generator(s) back to server.
8. Server logs the remote status to the database.
9. Remote status can be visualized through server application for higher login levels.

NLNoodvermogenpool Server
Windows 2008 R2
(located in data center)

MSSQL

LabVIEW
Web service

LabVIEW
Server Application
Serving Reentrant
Remote Panel

Task response

Create tasks

Query task

Log status

Open Server UI

OPC to be implemented in the near future. We'll then actually have access to an OPC server over a Virtual Private network connection where we can read tags that tell us to switch the pool(s) on or off.

'Call' via OPC

Major Imbalance!

Dutch electricity network maintained by TenneT

Uses supplemental operating reserves to maintain balance in the network.

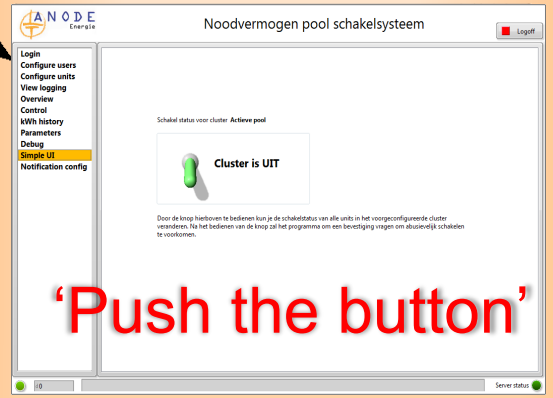
Notify Call Center

HTTPS, port 443
Units contact server every 10 seconds to check for new tasks.
Possible tasks: Switch, SendLogs, UpdateFirmware

HTTP, port 8001
Remote panels
Several login levels.

Call Center

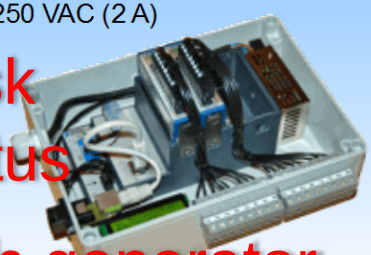
Operator takes call and pushes the button



'Push the button'

Remote supplemental reserve switching units
4 relay outputs 30 VDC (2 A), 60 VDC (1 A), 250 VAC (2 A)
4 DI 5-250 VDC, 10-250 VAC
cRIO-9075

Currently 30 units in the field.
To be scaled up to 90 by the end of the year.



Query task

Report status

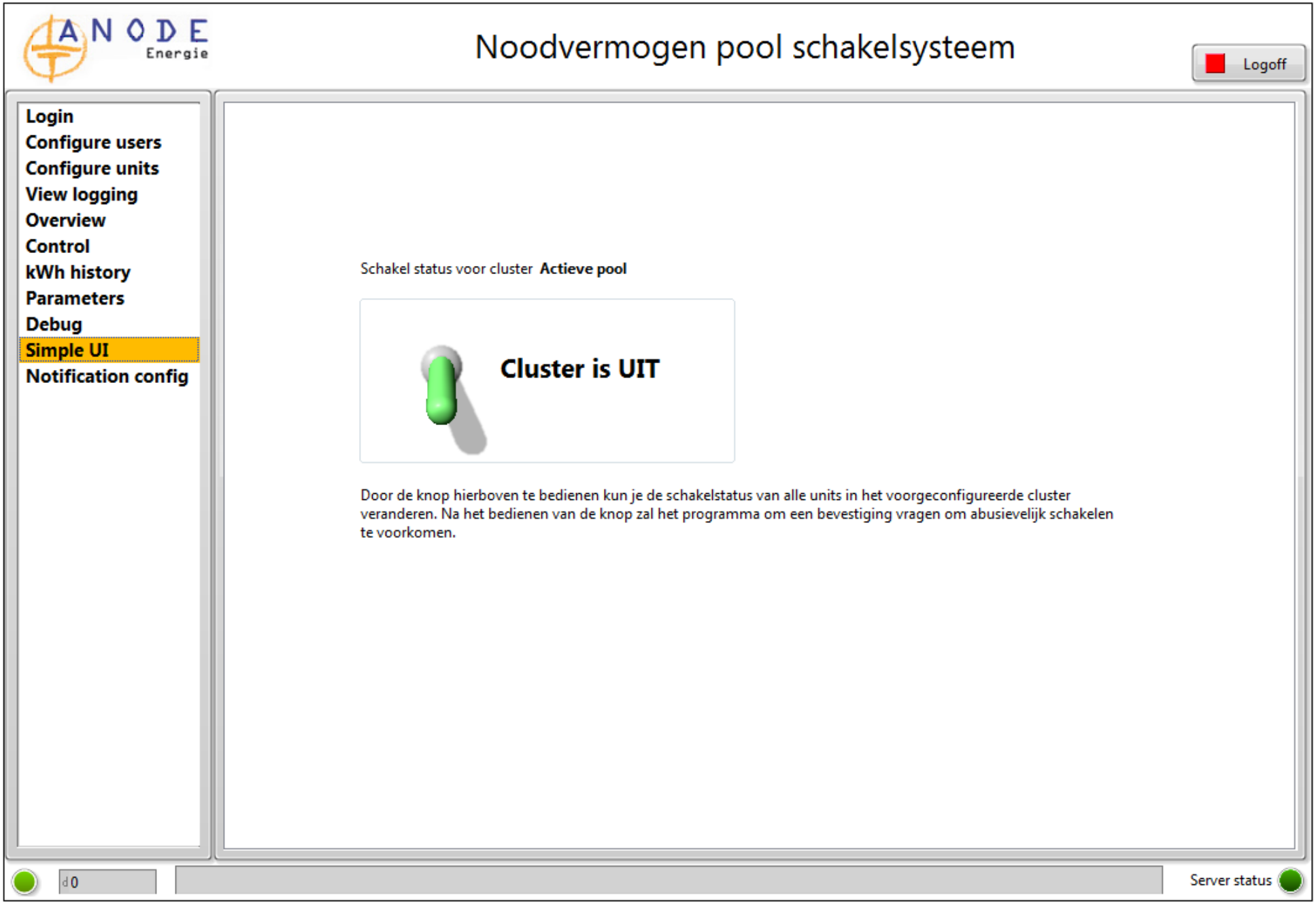
Switch generator

Local network config
via CompactRIO Web server

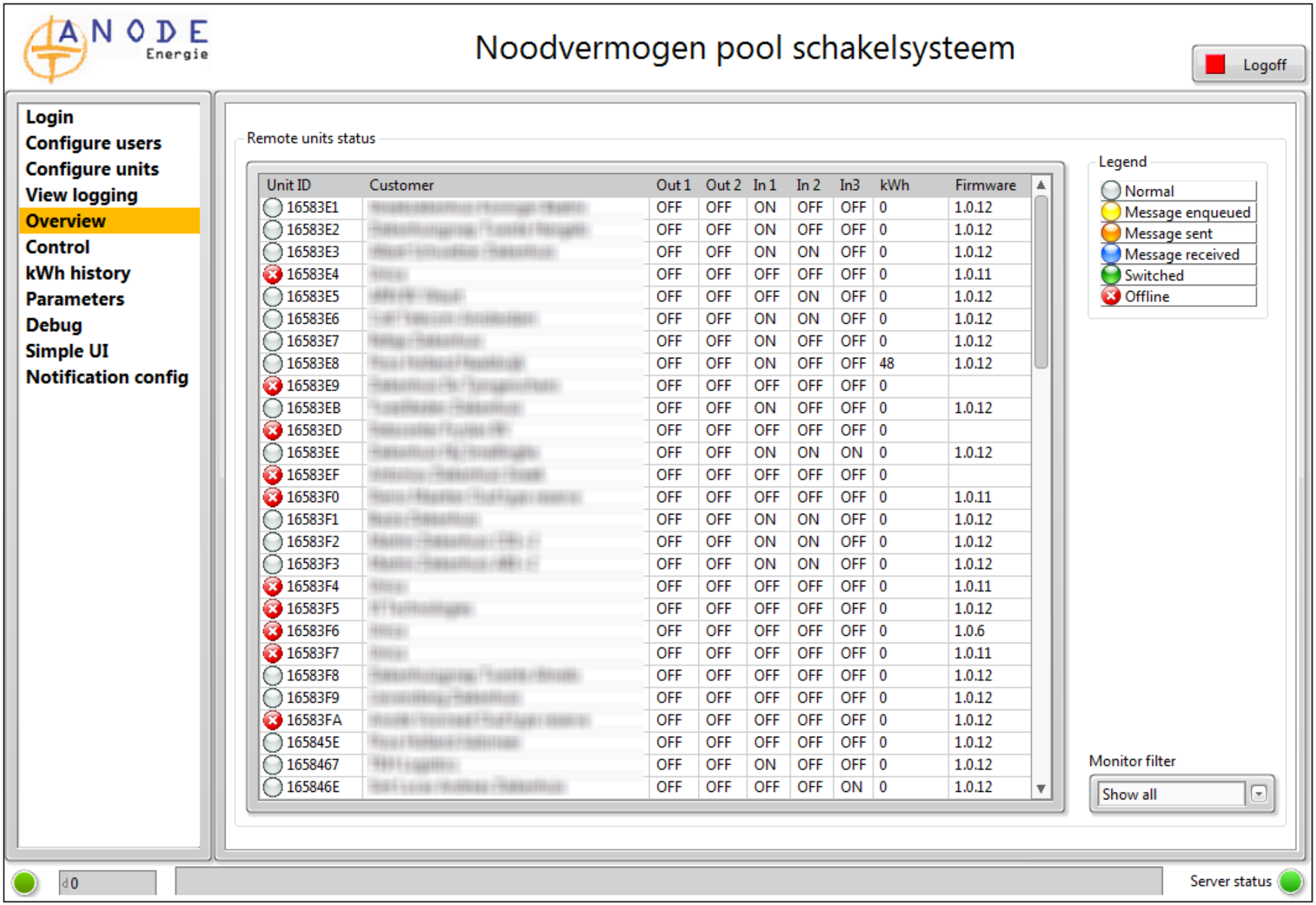
Pool participant
emergency generator(s)
Max. 2 per switching unit

Visualization

Switching


ANODE Energie
Noodvermogen pool schakelsysteem
Logoff
Login
Configure users
Configure units
View logging
Overview
Control
kWh history
Parameters
Debug
Simple UI
Notification config
Schakel status voor cluster Actieve pool
Cluster is UIT
Door de knop hierboven te bedienen kun je de schakelstatus van alle units in het voorgeconfigureerde cluster veranderen. Na het bedienen van de knop zal het programma om een bevestiging vragen om abusievelijk schakelen te voorkomen.
d 0
Server status

UI Overview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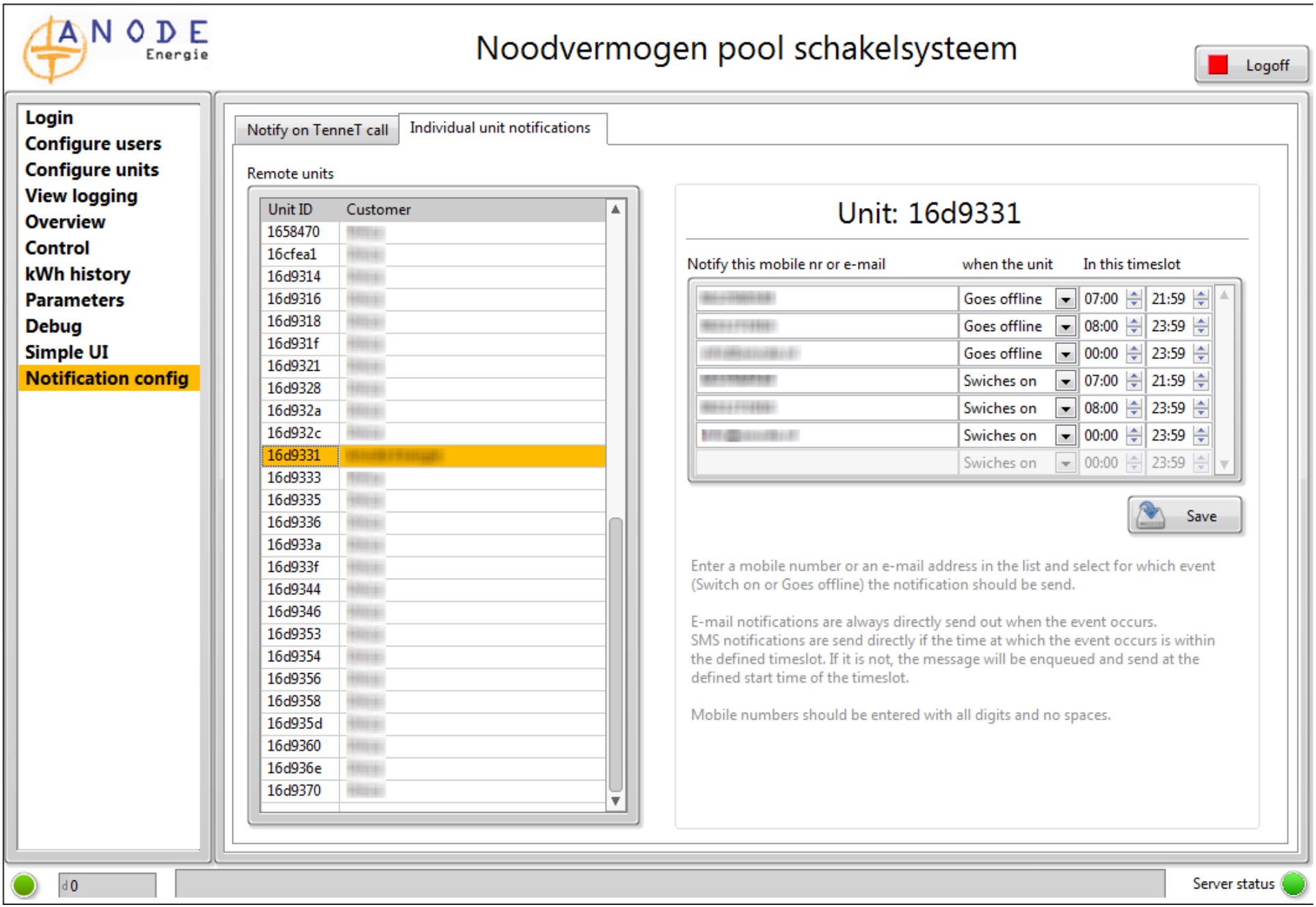
Remote units status
Unit ID Customer Out 1 Out 2 In 1 In 2 In3 kWh Firmware
16583E1 OFF OFF ON OFF OFF 0 1.0.12
16583E2 OFF OFF ON OFF OFF 0 1.0.12
16583E3 OFF OFF ON ON OFF 0 1.0.12
16583E4 OFF OFF OFF OFF OFF 0 1.0.11
16583E5 OFF OFF OFF ON OFF 0 1.0.12
16583E6 OFF OFF ON ON OFF 0 1.0.12
16583E7 OFF OFF ON OFF OFF 0 1.0.12
16583E8 OFF OFF ON OFF OFF 48 1.0.12
16583E9 OFF OFF OFF OFF OFF 0
16583EB OFF OFF ON OFF OFF 0 1.0.12
16583ED OFF OFF OFF OFF OFF 0
16583EE OFF OFF ON ON ON 0 1.0.12
16583EF OFF OFF OFF OFF OFF 0
16583F0 OFF OFF OFF OFF OFF 0 1.0.11
16583F1 OFF OFF ON ON OFF 0 1.0.12
16583F2 OFF OFF ON ON OFF 0 1.0.12
16583F3 OFF OFF ON ON OFF 0 1.0.12
16583F4 OFF OFF OFF OFF OFF 0 1.0.11
16583F5 OFF OFF OFF OFF OFF 0 1.0.12
16583F6 OFF OFF OFF OFF OFF 0 1.0.6
16583F7 OFF OFF OFF OFF OFF 0 1.0.11
16583F8 OFF OFF OFF OFF OFF 0 1.0.12
16583F9 OFF OFF OFF OFF OFF 0 1.0.12
16583FA OFF OFF OFF OFF OFF 0 1.0.12
165845E OFF OFF OFF OFF OFF 0 1.0.12
1658467 OFF OFF ON OFF OFF 0 1.0.12
165846E OFF OFF OFF OFF ON 0 1.0.12
Legend
Normal
Message enqueued
Message sent
Message received
Switched
Offline
Monitor filter
Show all
Server status

Notification config



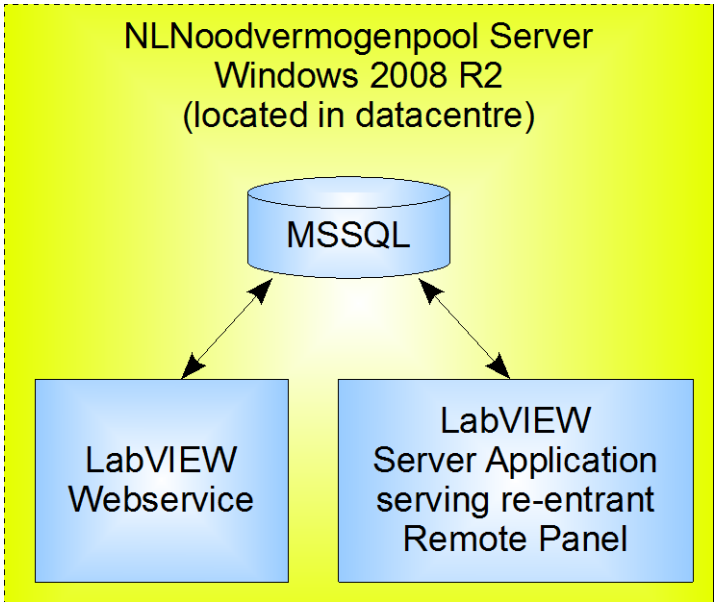
Communication

Call 'QueryTask' web method with current status of unit as parameters.

Server logs the status to the database

Server queries task for this unit from The database

Return task information in http response



Very basic FPGA program doing simple DIO and a counter for kWh pulses

Every 10 seconds the RT application connects with server via HTTPS by calling its web service methods.

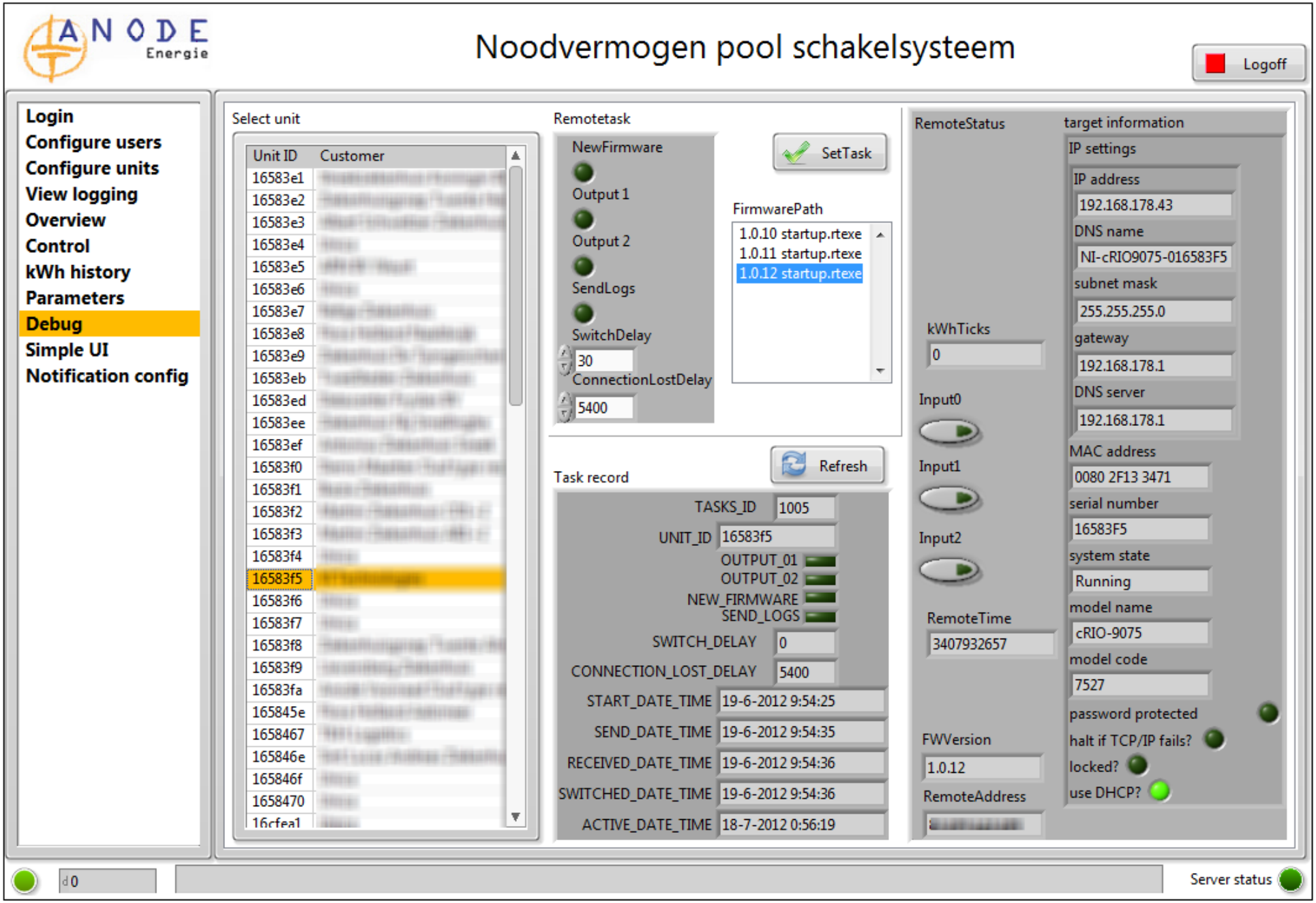
Other than for switching, a task can also be:

- an instruction to update the firmware
- upload the unit´s log files to the server

In such a case the unit would call the specific web service methods for those purposes.

There are two other web methods the unit can call to notify the server it has received and processed the task without error and to notify that the output relays actually have been actuated.

Debug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16583e1
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16583e3
16583e4
16583e5
16583e6
16583e7
16583e8
16583e9
16583eb
16583ed
16583ee
16583ef
16583f0
16583f1
16583f2
16583f3
16583f4
16583f5
16583f6
16583f7
16583f8
16583f9
16583fa
165845e
1658467
165846e
165846f
1658470
16cfea1
Remotetask
NewFirmware
Output 1
Output 2
SendLogs
SwitchDelay
30
ConnectionLostDelay
5400
SetTask
FirmwarePath
1.0.10 startup.rtexe
1.0.11 startup.rtexe
1.0.12 startup.rtexe
Refresh
Task record
TASKS_ID 1005
UNIT_ID 16583f5
OUTPUT_01
OUTPUT_02
NEW_FIRMWARE
SEND_LOGS
SWITCH_DELAY 0
CONNECTION_LOST_DELAY 5400
START_DATE_TIME 19-6-2012 9:54:25
SEND_DATE_TIME 19-6-2012 9:54:35
RECEIVED_DATE_TIME 19-6-2012 9:54:36
SWITCHED_DATE_TIME 19-6-2012 9:54:36
ACTIVE_DATE_TIME 18-7-2012 0:56:19
RemoteStatus
kWhTicks
0
Input0
Input1
Input2
RemoteTime
3407932657
FWVersion
1.0.12
RemoteAddress
target information
IP settings
IP address
192.168.178.43
DNS name
NI-cRIO9075-016583F5
subnet mask
255.255.255.0
gateway
192.168.178.1
DNS server
192.168.178.1
MAC address
0080 2F13 3471
serial number
16583F5
system state
Running
model name
cRIO-9075
model code
7527
password protected
halt if TCP/IP fails?
locked?
use DHCP?
Server status

Lessons Learned

- Remote frontpanels **are** usable for production code and a good way to create a rich UI and get it up and running fast
- For time sync via internet, use only IP-address with SNTP, not the FQDN
- TCP/IP waits 2 minutes before freeing up a connection after you close it, so with HTTP(S) communication, calling ‘CloseHandle’ does not actually free up your connection (and associated memory!) yet
- Being able to use LabVIEW on all fronts of this project (for the server (UI) application as well as the web-service and the programming of the Compact RIO remote units) really enabled us to get the most important parts of the system to go live in time

Thank you!

Download the presentation: www.vi-tech.nl

Stay in touch

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