

# Coordinating Distributed Energy Resources to Create a Supplemental Reserve Power Grid

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

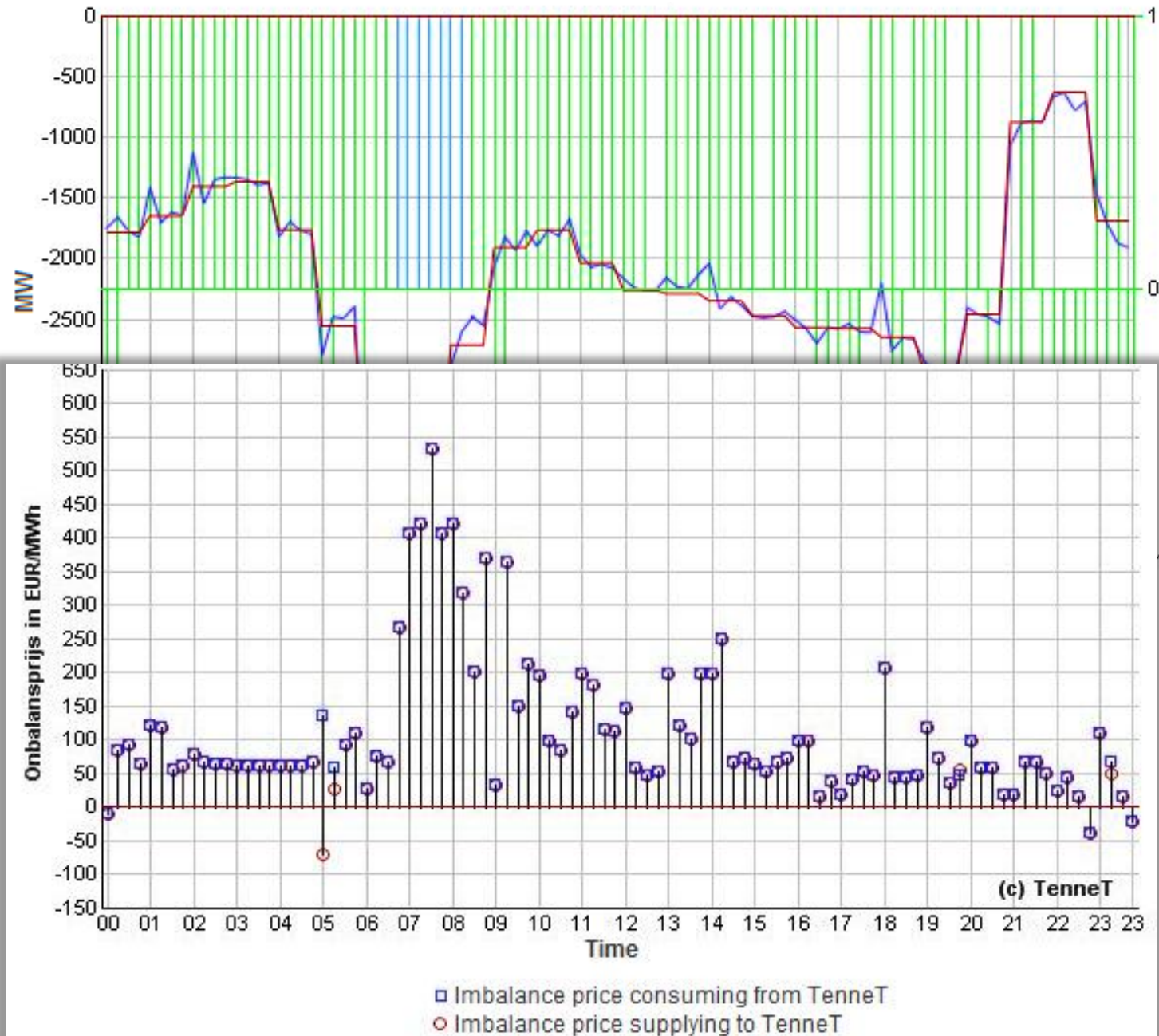
Jeffrey Habets



# 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

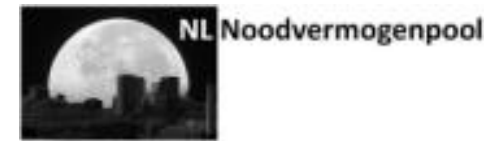


# Supplemental reserves in a pool

- 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



[www.nlrvp.nl](http://www.nlrvp.nl)



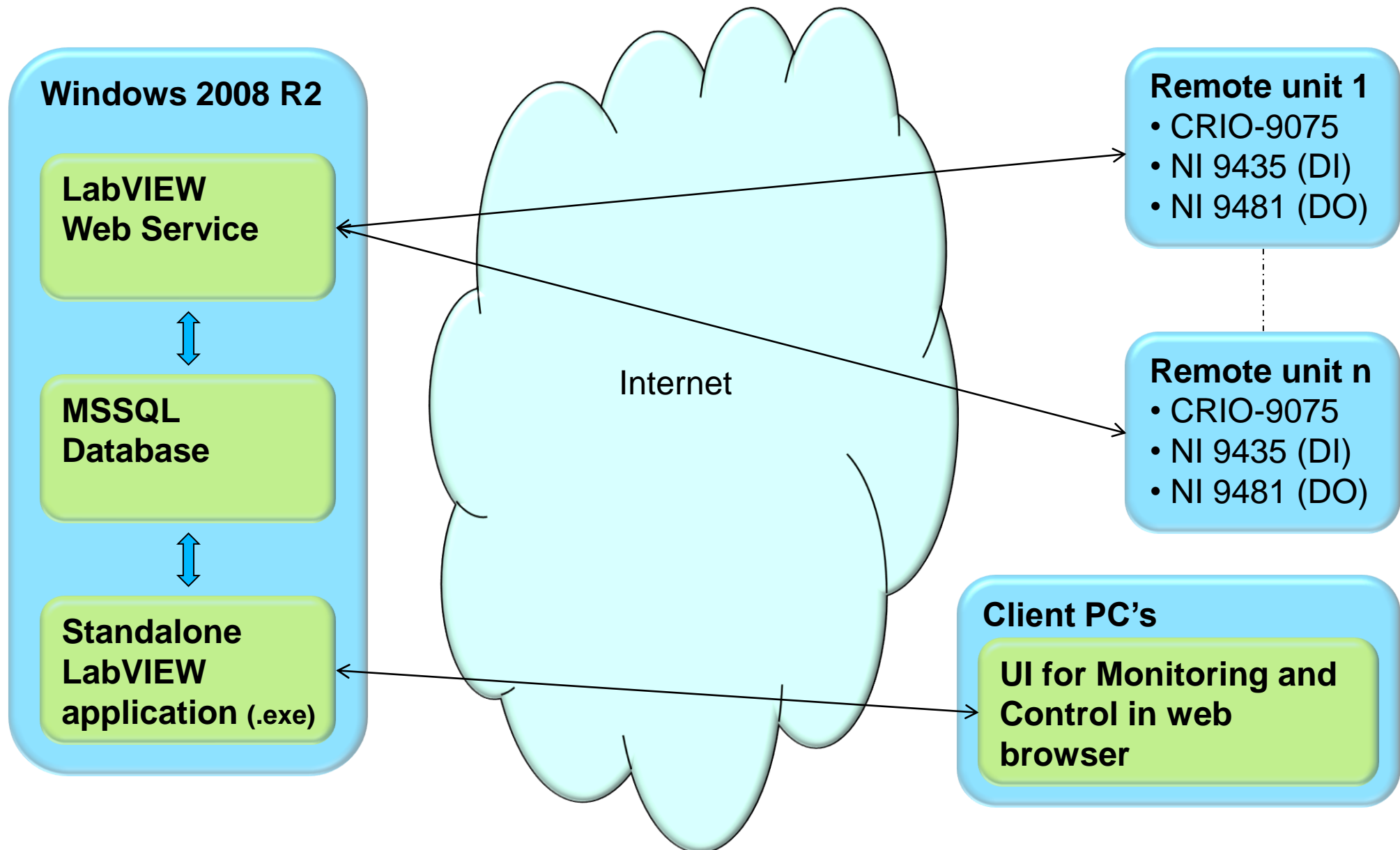
[www.anode.nl](http://www.anode.nl)



# 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

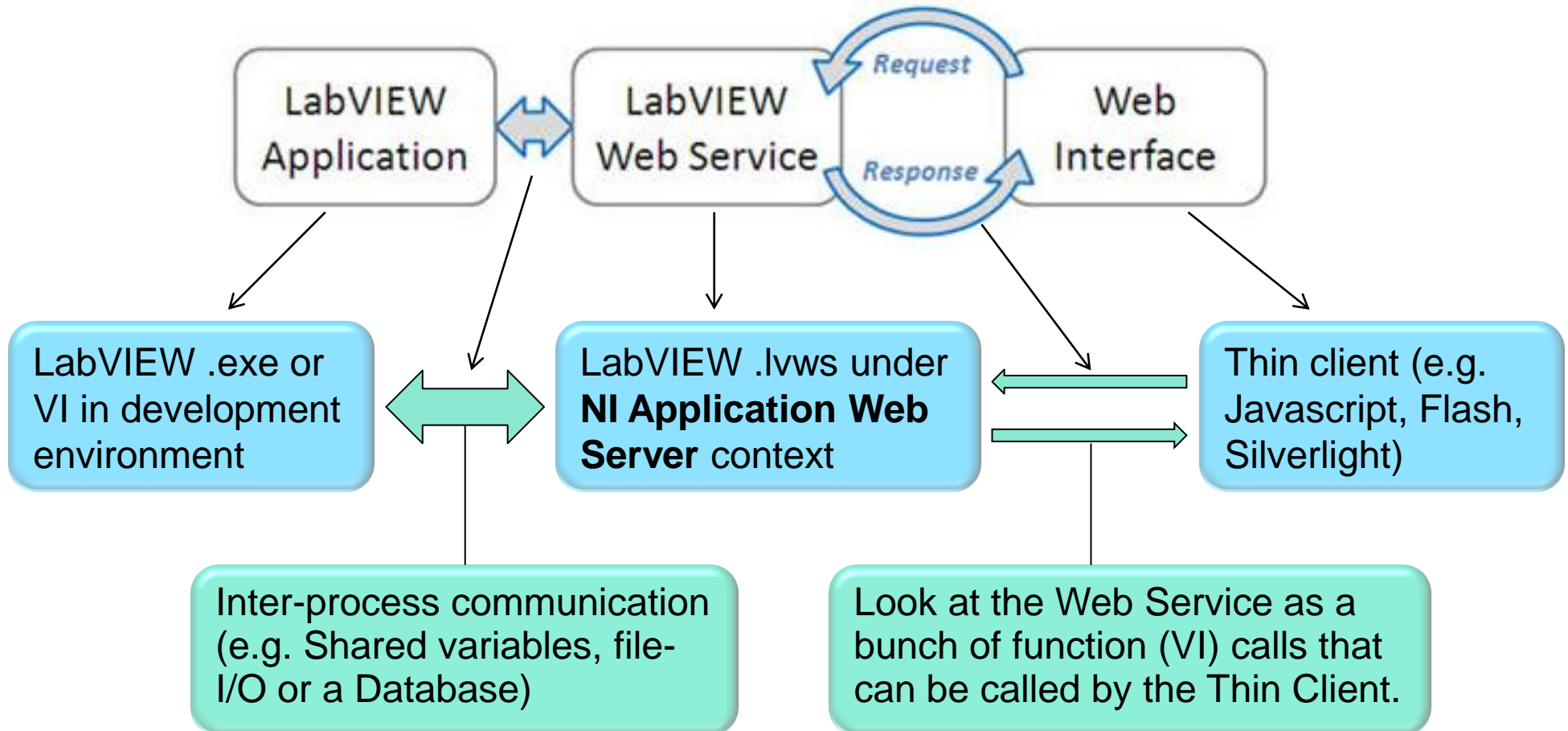


# Web Services

## Why web services?

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

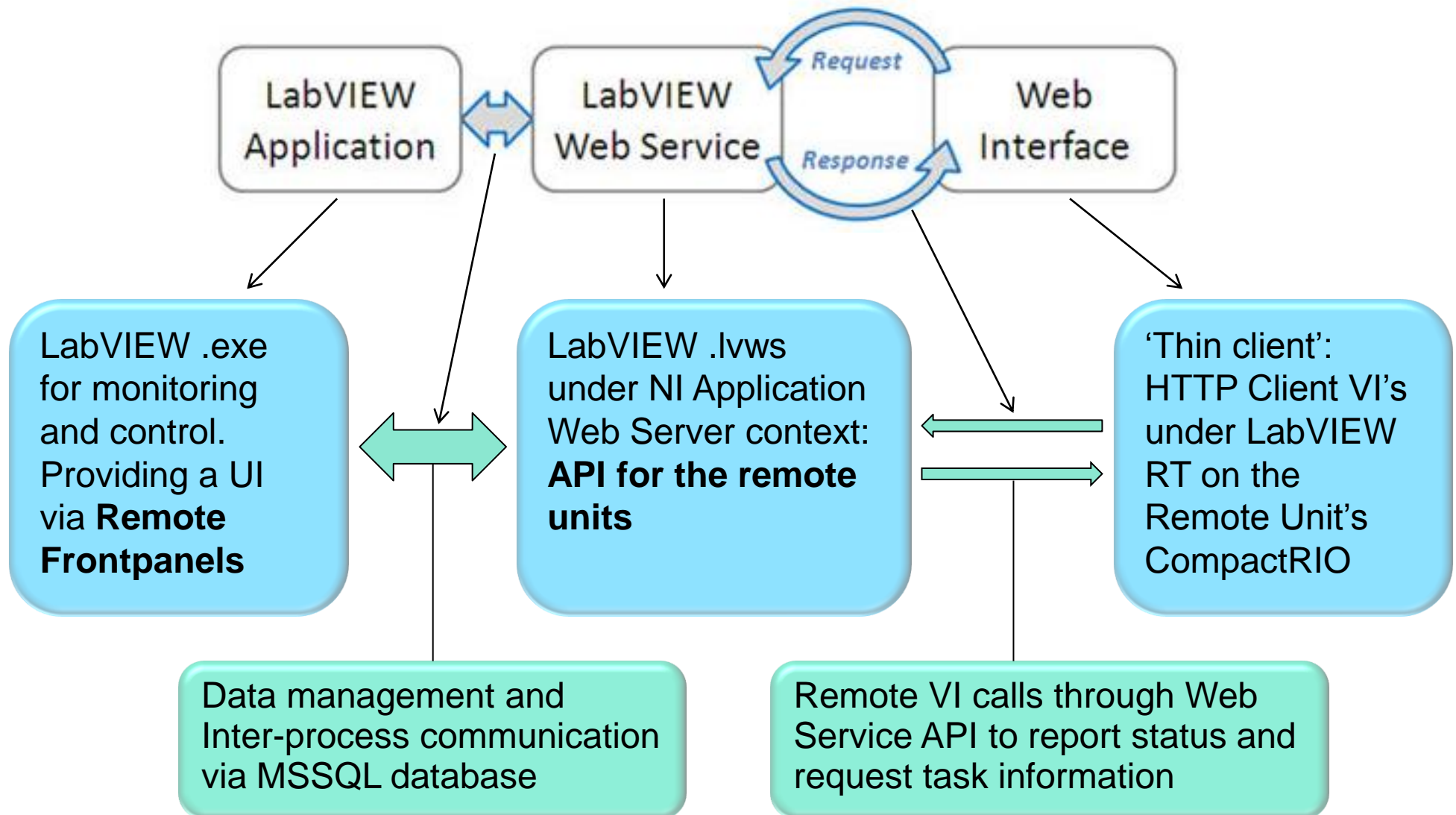
Standard http(s) traffic, no problem for most firewalls





# Web Services

So how does that map to our use-case?



1. TenneT needs supplemental reserve power.
2. Tennen 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.

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!

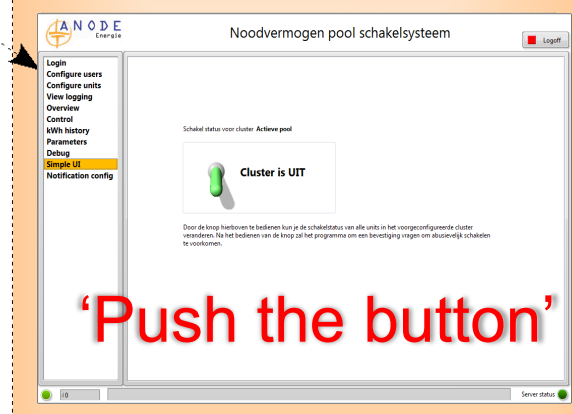
Dutch electricity network maintained by TenneT

Uses supplemental operating reserves to maintain balance in the network.

Notify Call Center

Call Center

Operator takes call and pushes the button



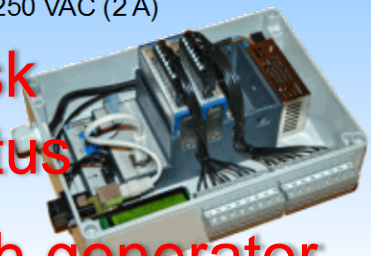
'Push the button'

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

**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

Query task  
Report status

Switch generator



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

Local network config via CompactRIO Web server




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

HTTP, port 8001  
Remote panels  
Several login levels.



Visualization

# Switching




## 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.


 d0

Server status 

# UI Overview






























## Noodvermogen pool schakelsysteem







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### Remote units status


Unit ID	Customer	Out 1	Out 2	In 1	In 2	In 3	kWh	Firmware
 16583E1	Wooncoöperatie Energie Noord	OFF	OFF	ON	OFF	OFF	0	1.0.12
 16583E2	Wooncoöperatie Energie Noord	OFF	OFF	ON	OFF	OFF	0	1.0.12
 16583E3	Wooncoöperatie Energie Noord	OFF	OFF	ON	ON	OFF	0	1.0.12
 16583E4	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.11
 16583E5	Wooncoöperatie Energie Noord	OFF	OFF	OFF	ON	OFF	0	1.0.12
 16583E6	Wooncoöperatie Energie Noord	OFF	OFF	ON	ON	OFF	0	1.0.12
 16583E7	Wooncoöperatie Energie Noord	OFF	OFF	ON	OFF	OFF	0	1.0.12
 16583E8	Wooncoöperatie Energie Noord	OFF	OFF	ON	OFF	OFF	48	1.0.12
 16583E9	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	
 16583EB	Wooncoöperatie Energie Noord	OFF	OFF	ON	OFF	OFF	0	1.0.12
 16583ED	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	
 16583EE	Wooncoöperatie Energie Noord	OFF	OFF	ON	ON	ON	0	1.0.12
 16583EF	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	
 16583F0	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.11
 16583F1	Wooncoöperatie Energie Noord	OFF	OFF	ON	ON	OFF	0	1.0.12
 16583F2	Wooncoöperatie Energie Noord	OFF	OFF	ON	ON	OFF	0	1.0.12
 16583F3	Wooncoöperatie Energie Noord	OFF	OFF	ON	ON	OFF	0	1.0.12
 16583F4	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.11
 16583F5	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.12
 16583F6	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.6
 16583F7	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.11
 16583F8	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.12
 16583F9	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.12
 16583FA	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.12
 165845E	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	OFF	0	1.0.12
 1658467	Wooncoöperatie Energie Noord	OFF	OFF	ON	OFF	OFF	0	1.0.12
 165846E	Wooncoöperatie Energie Noord	OFF	OFF	OFF	OFF	ON	0	1.0.12

Legend


-  Normal
-  Message enqueued
-  Message sent
-  Message received
-  Switched
-  Offline

Monitor filter

 d0

Server status 

# Notification config



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Notify on TenneT call Individual unit notifications

Remote units

Unit ID	Customer
1658470	
16cfea1	
16d9314	
16d9316	
16d9318	
16d931f	
16d9321	
16d9328	
16d932a	
16d932c	
<b>16d9331</b>	
16d9333	
16d9335	
16d9336	
16d933a	
16d933f	
16d9344	
16d9346	
16d9353	
16d9354	
16d9356	
16d9358	
16d935d	
16d9360	
16d936e	
16d9370	

### Unit: 16d9331

Notify this mobile nr or e-mail	when the unit	In this timeslot
<input type="text"/>	Goes offline	07:00 21:59
<input type="text"/>	Goes offline	08:00 23:59
<input type="text"/>	Goes offline	00:00 23:59
<input type="text"/>	Swiches on	07:00 21:59
<input type="text"/>	Swiches on	08:00 23:59
<input type="text"/>	Swiches on	00:00 23:59
<input type="text"/>	Swiches on	00:00 23:59

Save

Enter a mobile number or an e-mail address in the list and select for which event (Switch on or Goes offline) the notification should be send.

E-mail notifications are always directly send out when the event occurs.  
SMS notifications are send directly if the time at which the event occurs is within the defined timeslot. If it is not, the message will be enqueued and send at the defined start time of the timeslot.

Mobile numbers should be entered with all digits and no spaces.

d0

Server status



# Communication

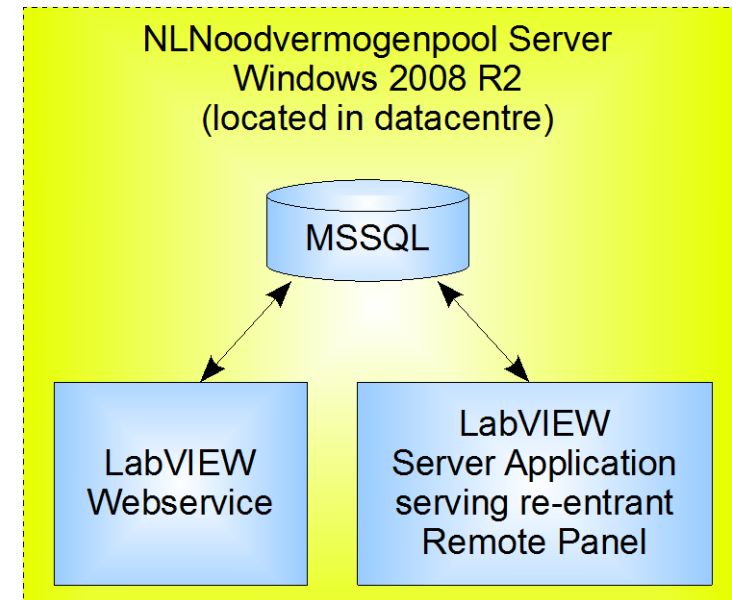


Call 'QueryTask' web method with current status of unit as parameters.

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.





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[kWh history](#)  
[Parameters](#)  
**[Debug](#)**  
[Simple UI](#)  
[Notification config](#)

Select unit

Unit ID	Customer
16583e1	
16583e2	
16583e3	
16583e4	
16583e5	
16583e6	
16583e7	
16583e8	
16583e9	
16583eb	
16583ed	
16583ee	
16583ef	
16583f0	
16583f1	
16583f2	
16583f3	
16583f4	
<b>16583f5</b>	
16583f6	
16583f7	
16583f8	
16583f9	
16583fa	
165845e	
1658467	
165846e	
165846f	
1658470	
16cfeal	

Remotetask

NewFirmware ☒ SetTask

Output 1 ☐

Output 2 ☐

SendLogs ☐

SwitchDelay

ConnectionLostDelay

FirmwarePath

- 1.0.10 startup.rtexe
- 1.0.11 startup.rtexe
- 1.0.12 startup.rtexe**

Task record

Refresh

TASKS_ID	UNIT_ID	OUTPUT_01	OUTPUT_02	NEW_FIRMWARE	SEND_LOGS	SWITCH_DELAY	CONNECTION_LOST_DELAY	START_DATE_TIME	SEND_DATE_TIME	RECEIVED_DATE_TIME	SWITCHED_DATE_TIME	ACTIVE_DATE_TIME
1005	16583f5	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0	5400	19-6-2012 9:54:25	19-6-2012 9:54:35	19-6-2012 9:54:36	19-6-2012 9:54:36	18-7-2012 0:56:19

RemoteStatus

target information

IP settings

IP address

DNS name

subnet mask

gateway

DNS server

MAC address

serial number

system state

model name

model code

password protected ☒

halt if TCP/IP fails? ☒

locked? ☒

use DHCP? ☒

kWhTicks

Input0 ☐

Input1 ☐

Input2 ☐

RemoteTime

FWVersion

RemoteAddress

d0

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](http://www.vi-tech.nl)

Stay in touch



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