

# **Process monitoring and control using Internet and cellular telephony**

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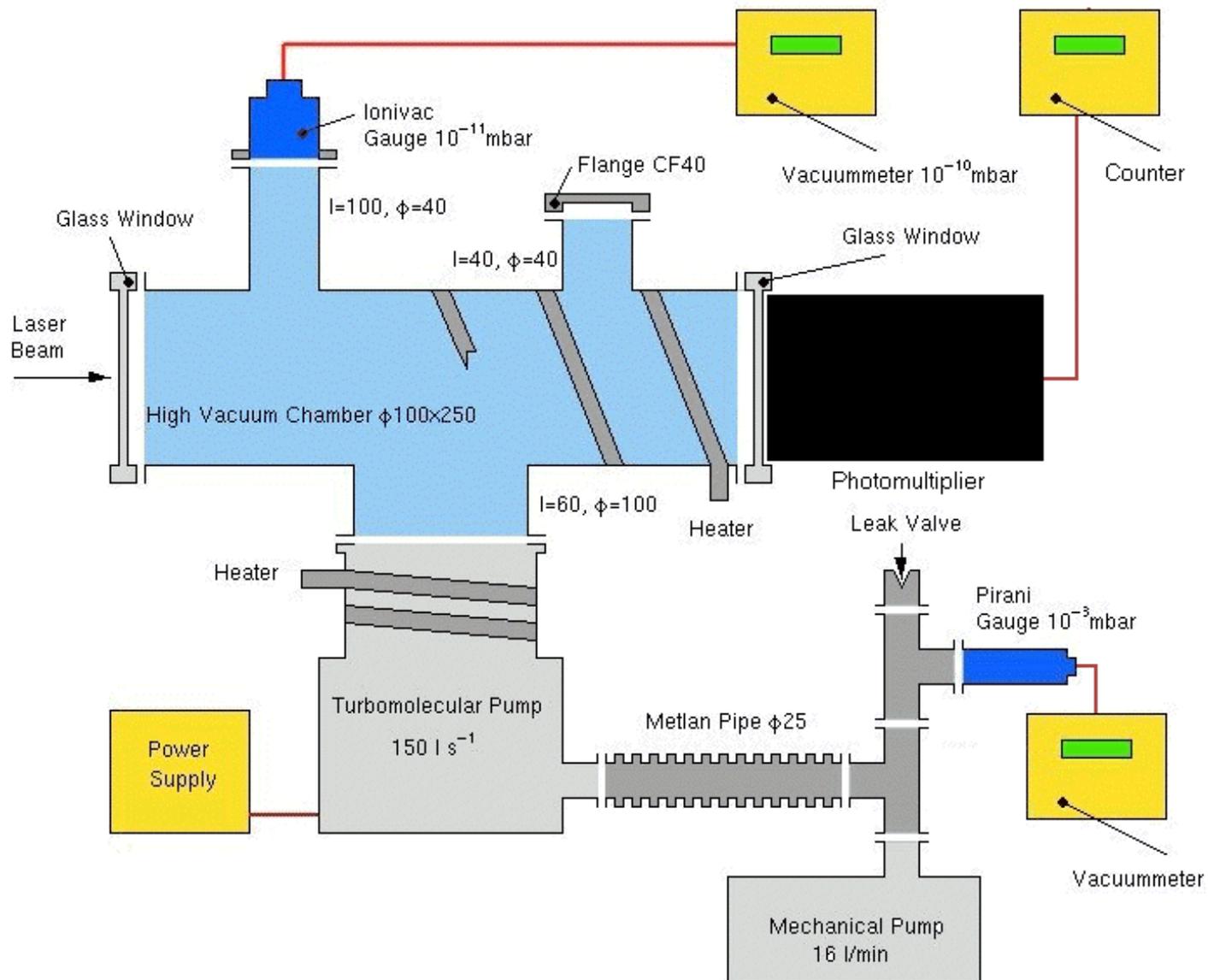
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Talk given at CUC 2002, September 25-27, Croatia

# Technical problem

- A scientific experiment was built at the Rudjer Boskovic Institute
- The experiment needed to be operational for ~100 days without interruption
- Too few people to organize shifts
- The experiment could not be run in a completely automatic way: occasional interventions from operator were needed
- Experiment needed to be run during vacations
- Fortunately experiment could have been run without human intervention

# The experiment



# Solution 1: the Internet

- We have built our own PC controllable interfacing hardware:
  - Master serial In/Out box with 56 input and 32 output bits
  - ADC with 13 channels - 4 ranges each
  - Sensor box for measuring temperatures
  - Gated counter for counting events
  - Z-box for power-failure safe operation with controllable switches and power regulators
- This hardware controls the experiment
- A steering program made of **CGI executables**, **HTML forms** and a **WEB server** makes possible to monitor and control the experiment over the WEB

# The steering program

- Specific routines (primitives) communicate to the hardware
- The **steering program** makes all these to work as a whole and to perform specific task(s) upon a request from the operator (scientist)
- A **steering program** is an interface between a scientist and the experiment - it makes use of graphics, buttons and input fields to communicate
- A **steering program** is not meant to make complex data analysis - this is done by other programs



# LOG ARCHIVE

<a href="#">zapis788.dat</a>	<a href="#">Download</a>
<a href="#">zapis787.dat</a>	<a href="#">Download</a>
<a href="#">zapis786.dat</a>	<a href="#">Download</a>
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<a href="#">zapis783.dat</a>	<a href="#">Download</a>
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<a href="#">zapis781.dat</a>	<a href="#">Download</a>
<a href="#">zapis780.dat</a>	<a href="#">Download</a>
<a href="#">zapis779.dat</a>	<a href="#">Download</a>
<a href="#">zapis778.dat</a>	<a href="#">Download</a>

<b>Broj tocaka :</b>	<input type="text" value="1000"/>	<b>Period uzorkovanja [s]:</b>	<input type="text" value="60"/>				
<b>Redoslijed uzorkovanja :</b>	<input type="text" value="background=1,signal=1,wait=0"/>						
<input type="button" value="Start"/>	<input type="button" value="Stop"/>	<input type="button" value="Status"/>	<input type="button" value="ADCC"/>	<input type="button" value="Temp"/>	<input type="button" value="Logfiles"/>	<input type="button" value="E-Mail"/>	<input type="button" value="Heat"/>
<input type="button" value="HStop"/>							



Counts	Time [s]	Time	Date	T <sub>PM</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>AMB</sub>	p [mbar]	Mode
0	0.0	16:36:40.62	05-06-2002	79.3	341	198.4	29.7	22.2	9.6e-11	U
0	60.3	16:37:40.91	05-06-2002	79.3	341	198.4	29.5	22.0	9.6e-11	B
0	120.6	16:38:41.30	05-06-2002	79.3	343	198.4	29.7	22.0	9.5e-11	S
0	180.9	16:39:41.49	05-06-2002	79.3	341	198.4	29.5	21.8	9.5e-11	B
0	241.2	16:40:41.78	05-06-2002	79.3	343	198.4	29.5	21.8	9.6e-11	S
0	300.1	16:41:40.70	05-06-2002	79.3	341	198.4	29.7	21.8	9.5e-11	B
0	360.4	16:42:40.99	05-06-2002	79.3	341	198.4	29.5	21.8	9.6e-11	S
0	420.7	16:43:41.28	05-06-2002	79.3	341	198.4	29.7	21.8	9.6e-11	B
0	481.0	16:44:41.60	05-06-2002	79.3	341	198.4	29.7	22.0	9.6e-11	S
0	541.3	16:45:41.89	05-06-2002	79.3	343	198.4	29.5	22.0	9.6e-11	B
0	600.9	16:46:41.54	05-06-2002	79.3	343	198.5	29.7	21.8	9.6e-11	S
0	661.2	16:47:41.83	05-06-2002	79.3	343	198.5	29.7	22.0	9.6e-11	B
0	720.1	16:48:40.76	05-06-2002	79.3	343	198.5	29.5	22.0	9.6e-11	S
0	780.4	16:49:41.05	05-06-2002	79.3	341	198.5	29.7	21.8	9.6e-11	B

Ispisuje se zapis : zapis630.dat

Broj točaka :	<input type="text" value="1000"/>	Period uzorkovanja [s]:	<input type="text" value="60"/>				
<u>Redoslijed uzorkovanja :</u>	<input type="text" value="background=1, signal=1, wait=0"/>						
Start	Stop	Status	ADCC	Temp	Logfiles	E-Mail	Heat
HStop							

COMPUTER	UP	(UP/DOWN)
LASER	OFF	(ON/OFF)
MECH. PUMP STATUS	PUMPING	(PUMPING/OFF)
TURBO PUMP STATUS	PUMPING	(PUMPING/OFF)
COOLING	ON-LINE	(ON-LINE/OFF-LINE)
PM HIGH VOLTAGE	900 V	
PM TEMPERATURE	27.2 C	
HEATER0 TEMPERATURE	28.97 C	
HEATER1 TEMPERATURE	29.08 C	
T4 TEMPERATURE	30.85 C	
T6 TEMPERATURE	17.33 C	
LASER POWER SWITCH	ON	(ON/OFF)
PUMPS POWER SWITCH	ON	(ON/OFF)
HEATER0 PWR SWITCH	0	(0-15)
DATA TAKING STATUS	S	(BACK/SIGN/STOP/HEAT/WAIT)
RUNNING SINCE	02:04:44 04-Sep-2002	
FILE & LAST POINT	zapis791.dat, 463	
MODE REPEAT PATTERN	signal=10	
GAUGE PRESSURE	0 mbar	
ROOM TEMPERATURE	18.0372 C	
TIME/DATE	09:47:45 04-Sep-2002	

# Temperatures page

- It is possible to monitor all measured temperatures instantly
- A set of thresholds defines automatic actions (ex. over-heat protection)

	T [°C]	T <sub>thr</sub> [°C]
T <sub>PM</sub>	27.7	-2.3
T <sub>2</sub>	29.7	84.9
T <sub>3</sub>	29.4	25.2
T <sub>4</sub>	30.0	12.3
T <sub>AMB</sub>	17.5	

# ADC voltages page

CHANNEL	RANGE	VALUE		CHANNEL	RANGE	VALUE
0	0	0.497		8	0	0.907
1	0	0.514		9	2	0.003
2	0	0.512		10	3	5.025
3	0	0.517		11	0	0.001
4	1	1.379		12	0	0.410
5	2	2.271		13	0	0.414
6	1	1.653		14	2	0.004
7	1	1.531		15	0	-0.001

COUNTER : 0

# SMS Alarms & Reports

E-mail	Time
38598800901@cronet.tel.hr	08:00 12:00 19:00
Stipevic.Mario@irb.hr	12:10
Kresimir.Jakovcic@irb.hr	13:30 21:00

<b>Action</b>	<b>E-Mail</b>	<input type="text" value="Kresimir.Jakovcic@irb.hr"/>	<input type="button" value="Submit"/>
<b>Add</b> <input type="button" value="v"/>	<b>Times</b>	<input type="text" value="13:30 21:00"/>	

## WEB solution - strong points:

- an experiment or a process may be controlled from *almost* anywhere
- a lot of data and graphics can be displayed

## WEB solution - weak points:

- the *online Internet* connection is needed for the server side
- the *offline Internet* is sufficient for the client side to control the experiment, but then alarms aren't possible (1-wayness)
- both *online* and *offline Internet* are poorly available in Croatia, especially for people who are travelling
- a notebook PC + GSM + modem -> not practical, expensive slow. (Future solution - Web capable mobiles ?)

We tried to overcome the weak points by the Solution 2

# Solution 2: SMS Robot

- SMS Robot is a virtual being (program) who has an e-mail account on the local computer
- Relays messages to the steering daemon
- A set of alarms can be preset
- Must be able to reply

General incoming message format:

**command** [parameter list] [authentication]

## **SMS (cellular phones) solution - strong points:**

- Cellular network signal available virtually everywhere
- Enables 2-way communication
- Practical: small & light, can be used at any place and discretely, enables great autonomy (~5 days without rech.)

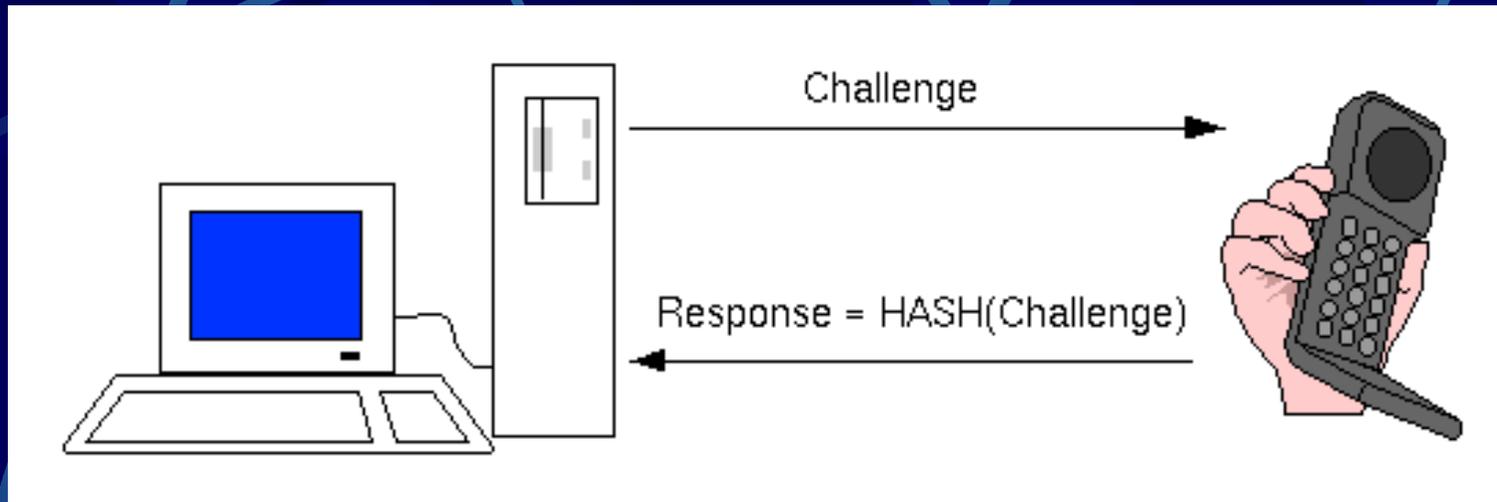
## **SMS (cellular phones) solution - weak points:**

- Poor displaying capability -> no graphics (yet), text only
- Only small data transfer possible
- Sometimes unreliable

# Security

- Web pages are secured by a password and the https
- SMS messages are authenticated by a challenge-response protocol: at the end of Robot's message there is a challenge used to authenticate the next request
- For the first request or if the chain gets broken -> send an empty message to receive a challenge
- SMS authentication may be turned ON and OFF

# SMS authentication scheme



- Server sends a random **Challenge**
  - Client responds by hashing it - **Response** seems random
  - The HASH function is secret
- (Future development -> use of a token)

# Conclusions

- Existing WEB tools can be used to efficiently construct programs for management of processes
- Such programs can be easily interfaced to e-mail capable mobile phones by means of an SMS Robot
- This Internet technology should be preferred over classical programming because it offers automatically the possibility to manage the process from a distance
- **HOWEVER**, the Internet still needs to be much more available