

SYSTEM-OF-SYSTEMS THAT ACT LOCALLY FOR OPTIMIZING GLOBALLY

EU FP7 - SMALL/MEDIUM-SCALE FOCUSED RESEARCH PROJECT (STREP)
FP7-ICT-2013.3.4: ADVANCED COMPUTING, EMBEDDED AND CONTROL SYSTEMS
D) FROM ANALYZING TO CONTROLLING BEHAVIOUR OF SYSTEM OF SYSTEMS (SOS)

Local4Global Consortium Meeting

Building Use Case – WP6 Evaluation
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Munich, Germany

Local⁴Global

Contact Information

For information regarding this Project: Check the Project Web-Site: <http://local4global-fp7.eu>

Participants	
1	CERTH - Centre for Research and Technology
2	ETHZ – Eidgenössische Technische Hochschule Zürich
3	RWTH – RWTH Aachen University
4	IK4 – IK4 TEKNIKER
5	TRV – TRANSVER GmbH
6	TUC – Technical University of Crete
7	TUM – Technische Universität München

Project Acronym: Local4Global

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Program Name:

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Progress in equipment expansion (1)

- Equipment expansion improves the evaluation due to additional information
- Equipment expansion offers further control issues and interactions than the already existing equipment does (→ variations of the Local4Global experiments)
- New equipment:
 - BELIMO „EnergyValve“
 - Complete control units for a water based heat exchanger loop
 - Sensors: temperatures (supply and return line), volume flow
 - Actuator: ball valve with electrical propulsion
 - Special: distributed controller (JAVA)
 - Control modes (flow, power, position)
- New data points



Source: BELIMO

Progress in equipment expansion (2)

- Local4Global BUC TSoS consists of
 - 7 conference systems with CCA and AC
 - 6 office systems with CCA and FVU
- 32 of 38 EnergyValves are installed
- Final implementation until the end of February
- From then on base case data will be gathered
- Next steps:
 - Developing tailored reports
 - Programming the evaluation procedures
 - Adjustment of experimental planning



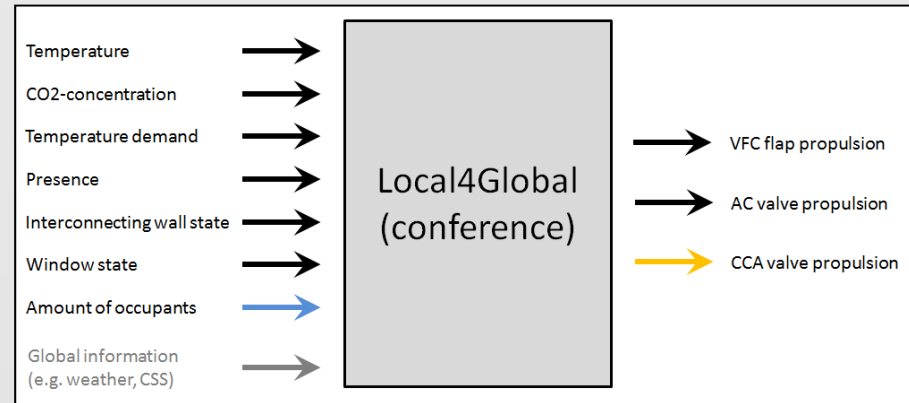
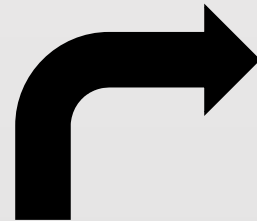
Example: measurement series CCA loop



List of data points

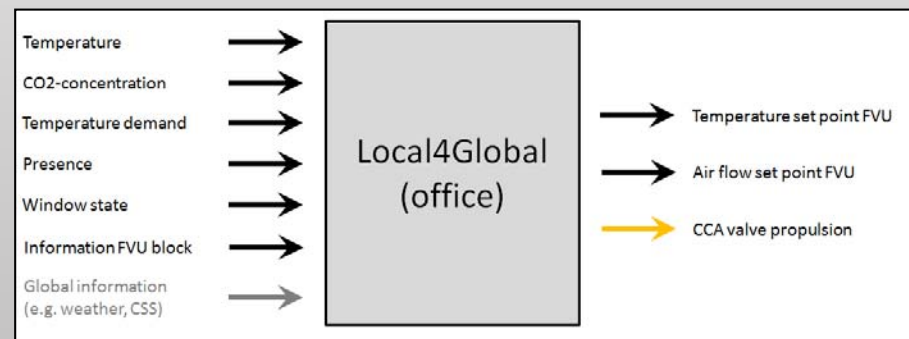
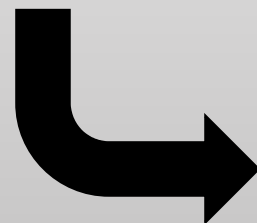
A	B	C	F	G	H	I	J	M	N	O	P
Nr.	Room	Data point	name L4G	Usage	Information	VarName	Unit	var type	min	max	set
1	00.19	interconnecting wall 19/20	IS_0019_0020	control	local	Y[1]	---	binary			0,1
2	00.20	interconnecting wall 20/21	IS_0020_0021	control	local	Y[2]	---	binary			0,1
3	00.19	window sensor	WS_0019	control	local	Y[3]	---	binary			0,1
4	00.20	window sensor	WS_0020	control	local	Y[4]	---	binary			0,1
5	00.21	window sensor	WS_0021	control	local	Y[5]	---	binary			0,1
6	00.19	presence sensor	PS_0019	control	local	Y[6]	---	binary			0,1
7	00.20	presence sensor	PS_0020	control	local	Y[7]	---	binary			0,1
8	00.21	presence sensor	PS_0021	control	local	Y[8]	---	binary			0,1
9	00.19	room temperature demand value	TD_0019	control	local	Y[9]	K	float	-3	3	
10	00.20	room temperature demand value	TD_0020	control	local	Y[10]	K	float	-3	3	
11	00.21	room temperature demand value	TD_0021	control	local	Y[11]	K	float	-3	3	
12	00.19	room temperature	T_0019	control	local	Y[12]	°C	float	20	26	
Nr.	Room	Data point	name L4G	Usage	Information	VarName	Unit	var type	min	max	set
121	outside	forecast outside temperature		verification	global	Y[121]	°C	float			
122	outside	forecast solar radiation - scattered		verification	not available	Y[122]	W/m ²	float			
123	outside	forecast solar radiation - global		verification	not available	Y[123]	W/m ²	float			
124	00.19	comfort score		evaluation	local	Y[124]		int	0	100	
125	00.20	comfort score		evaluation	local	Y[125]		int	0	100	
126	00.21	comfort score		evaluation	local	Y[126]		int	0	100	
127	00.19	exergy difference		evaluation	virtual	Y[127]	kW	float			
128	00.20	exergy difference		evaluation	virtual	Y[128]	kW	float			
129	00.21	exergy difference		evaluation	virtual	Y[129]	kW	float			
130	00.19	energy consumption		optimization	virtual	Y[130]	kWh/a	float			
131	00.20	energy consumption		optimization	virtual	Y[131]	kWh/a	float			
132	00.21	energy consumption		optimization	virtual	Y[132]	kWh/a	float			
133	all	overall energy consumption		optimization	virtual	Y[133]	kWh/a	float			
134	all	energy consumption in path A		optimization	virtual	Y[134]	kWh/a	float			
135	all	energy consumption in path B		optimization	virtual	Y[135]	kWh/a	float			
136	all	energy consumption in path C		optimization	virtual	Y[136]	kWh/a	float			
137	all	energy consumption in path D		optimization	virtual	Y[137]	kWh/a	float			
138	all	energy consumption in path SA		optimization	virtual	Y[138]	kWh/a	float			
139	00.19	renewable energy consumed		optimization	virtual	Y[139]	kWh/a	float			
140	00.20	renewable energy consumed		optimization	virtual	Y[140]	kWh/a	float			
141	00.21	renewable energy consumed		optimization	virtual	Y[141]	kWh/a	float			
142	all	overall renewable energy consumed		optimization	virtual	Y[142]	kWh/a	float			
143	00.19	NEC		optimization	virtual	Y[143]	kWh/a	float			
144	00.20	NEC		optimization	virtual	Y[144]	kWh/a	float			
145	00.21	NEC		optimization	virtual	Y[145]	kWh/a	float			
146	all	overall NEC		optimization	virtual	Y[146]	kWh/a	float			

Control task



Next steps:

- Adjust control functionality
- Adjust data exchange



BUC Roadmap

Phase	A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	D
Level	System	System	SoS	SoS	System	SoS	SoS	SoS	SoS	SoS	SoS
Objective	functional testing	functional testing	functional testing	validation	functional testing	functional testing	validation	functional testing	validation	operation	artificial circumstances
Scope	single small conference system	single large conference system	group of small conference systems	group of small conference systems	single office system	group of office systems	group of office systems	L4G building TSoS	L4G building TSoS	L4G building TSoS	L4G building TSoS
Off. 10.09	Ref.	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G	L4G	L4G
Off. 10.10	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G	L4G	L4G	L4G
Off. 10.11	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Off. 10.12	Ref.	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G	L4G	L4G
Off. 10.25	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G
Off. 10.26	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Off. 10.27	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G
Off. 10.28	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G
Conf. 00.17	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G
Conf. 00.18	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Conf. 00.19	Ref.	Ref.	L4G	L4G	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G
Conf. 00.20	L4G	Ref.	L4G	L4G	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G
Conf. 00.21	Ref.	Ref.	L4G	L4G	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G
Conf. 00.23	Ref.	L4G	Ref.	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G
Conf. 00.24	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	L4G	L4G	L4G	L4G

LEGEND

L4G := controlled by Local4Global algorithm

Ref. := controlled by current control strategy



1st evaluation results
(small TSoS)

Functional testing

Implementing control algorithm
Connecting to data points
Activating L4G control
Runtime observation

Validation

Set-up of simulation
Editing data
Simulation run
Documenting results

Operation

Set-up of experimental schedule
Activating operation
Runtime observation
Troubleshooting

Artificial circumstances

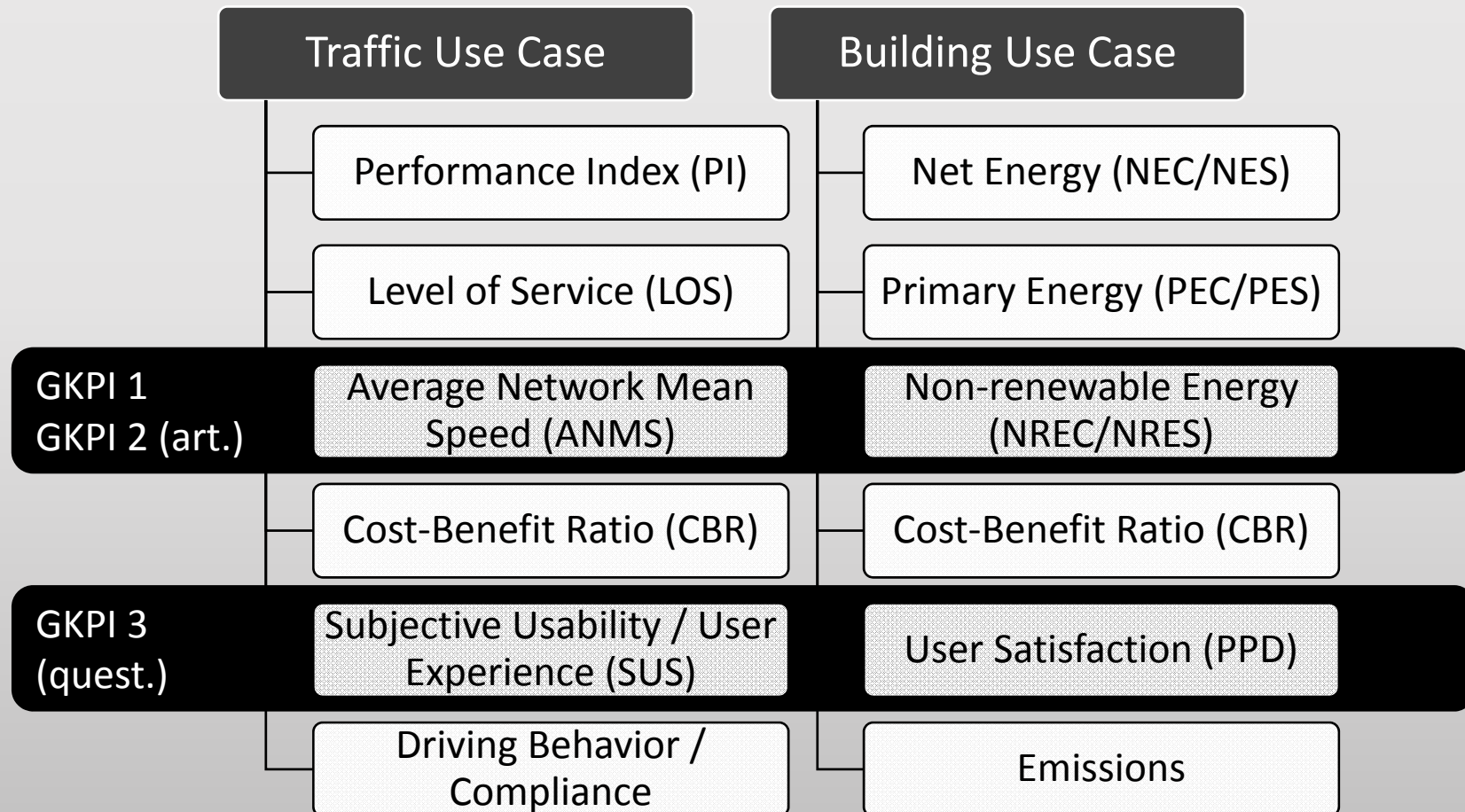
Set-up of experimental schedule
Runtime observation
Documenting results

Evaluation plan - revision

Index	Description	Target Improvement	Main Objective
GKPI 1	<i>Traffic Use Case:</i> Difference in terms of daily average network speed	30 %	O1, O2, O3
	<i>Building Use Case:</i> Difference in terms of daily average energy consumption from non-renewable sources while maintaining users' comfort (Fanger Factor) at an acceptable level		
GKPI 2	Equal to GKPI 1, but when major (artificial) incidents are present	30 %	O1, O2, O3
GKPI 3	Users' satisfaction metric to be calculated through questionnaires	80 %	O1, O2, O3

REVISION: Target value, not improvement

Evaluation plan - base KPI



Evaluation plan - particularization

- D6.1.1 - Evaluation plan 1st version → basic evaluation strategy
- The project objectives can be satisfied by that
- D6.1.2 - Final evaluation plan → particularization possible
- Suggestions for particularization:
 - Control quality (error, settling time, ...)
 - Step response (dynamic behavior)
 - Reaction on disturbances (artificial circumstances):
 - Changing global parameters [simulative]
 - Malfunction of a distribution path (system failure) [simulative and real]
 - Malfunction in communication (system return) [simulative]
 - Changing orchestration (emergent behavior) [simulative]
 - Enlargement
 - Usage
- Other ideas and inspiration (consortium)

Thank you, any questions...

References

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Upcoming paper, *System of Systems theory as a new perspective on building control*, European Control Conference ECC 2015, Linz, 2015

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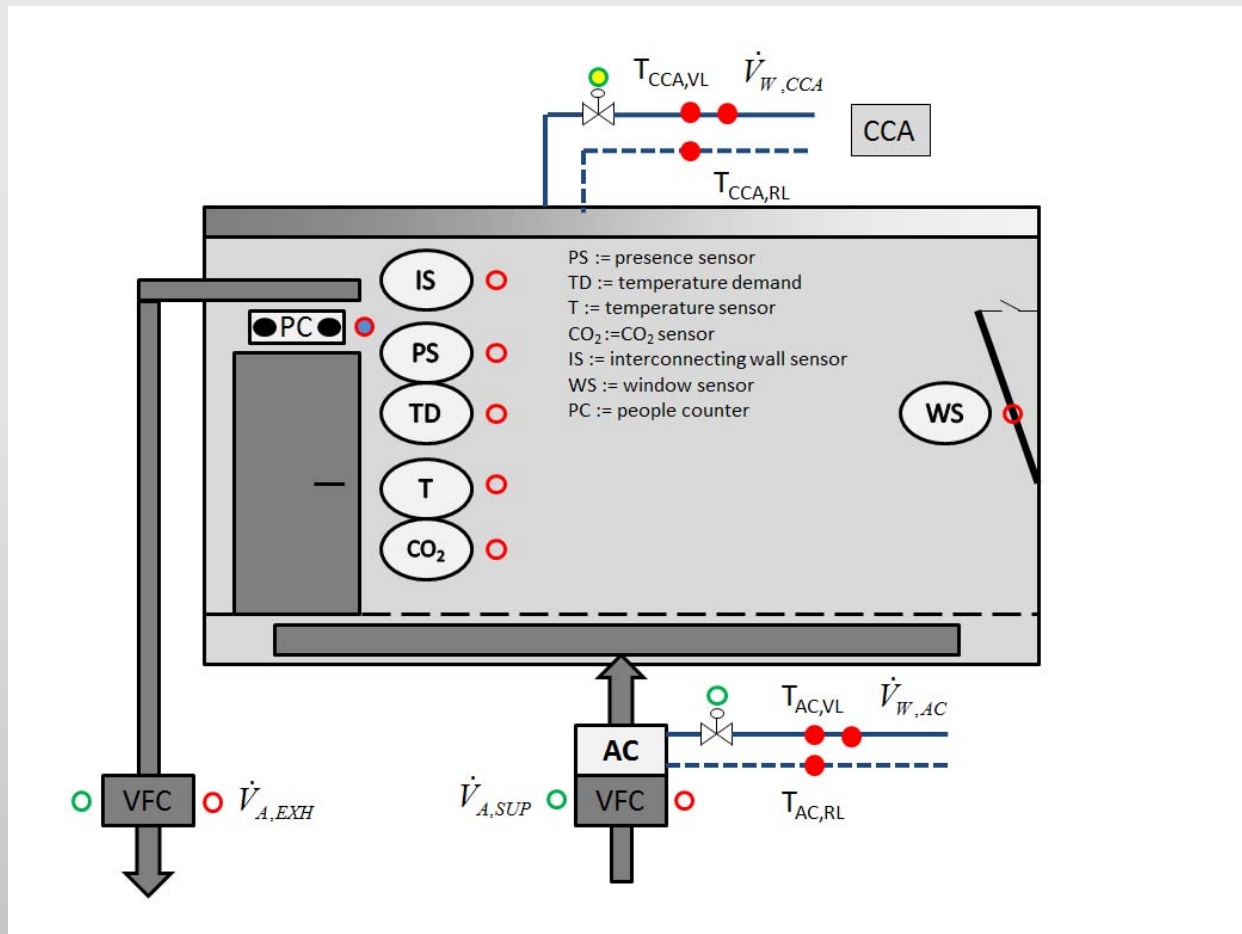
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Conference constituent system



Office constituent system

