Collaborative Project
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WIDE
Decentralized and Wireless Control of Large-Scale Systems

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Dissemination level	
PU	Public
PP	Restricted to other programme participants (including the Commission Services)
RE	Restricted to a group specified by the consortium (including the Commission Services)
→**CO**	Confidential, only for members of the consortium (including the Commission Services)

Executive summary
This report describes the key activity of WIDE consortium on receiving feedback on project results from industrial communities and possible end-users.

Contents

1 Introduction

This report summarizes the activity of WIDE consortium in disseminating results of WIDE in the industrial community and feedback which has been received from the community to the date. The key initiative in this direction was establishing an End-user panel consisting of 10 experts working in the areas of control and wireless in a number of industries. Two teleconference meetings were organized – one presenting WIDE research plan and early results, the other one presenting major WIDE results before the end of the project. This meeting was organized and hosted by HPL and contributed by other partners of the consortium.

Further dissemination activities in the industry involved presentation of WIDE results by HPL within its parent organization – Honeywell International at technological symposia and to people responsible for R&D in other divisions and business units.

2 End-User Panel

Introduction

End-user panel was established in early 2010. Declared objectives of this panel were as follows:

>   Getting a feedback for planning and executing project activities

>   Dissemination of project results in the industrial community.

The activities of the panel were planned from the beginning as virtual teleconference meetings, where members of WIDE consortium presented project objectives and its results to the industrial members of the panel, following a discussion, and collecting feedback forms which were distributed among the participants.

Panel members

Recruiting panel members was more complicated than expected. It was assumed that HPL will attract people responsible for technology of Honeywell customers, and similarly, academic partners will attract people with whom they cooperate with on project basis. The problem was that the objectives of WIDE were at, that time, somewhat distant for the customers of HPL, and marketing people were somewhat reluctant to share their contact with the customer base. Therefore, we approached our peers in R&D departments of companies of various industries who are more open to innovative technologies. We should note that after achieving important results in WIDE in wireless technology, and in particular, a successful development a new distributed MPC solution of water networks, marketing and

business development people are willing to promote these achievements among the customers.

After sending the invitation to our contacts in relevant industrial organizations, a number of distinguished researchers and engineers expressed their interest to participate in the end-user panel, whose list is in Table 1. In this table, a professor of Czech Technical University Zdeněk Hurák is included for the reason that he is active in the area of wireless networks and involved in industrial projects. Dr Bay is no longer active in the areas of WIDE, but previously he worked as a Chief Scientist for the US Air Force Research Laboratory and for DARPA. In both assignments, he was involved in a number of projects on distributed control and wireless networks.

Table 1

Name	Organization	E-mail
John Bay	Assured Information Security, Inc	jsbay14@gmail.com
Per Brath	Vestas Technology R&D	pebr@vestas.com
Julie Buckland	Ford Research & Advanced Engineering	jbucklan@ford.com
Ken Butts	Toyota	ken.butts@tema.toyota.com
Stefano di Cairano	Ford Research & Advanced Engineering	sdicaira@ford.com
Francesco Cuzzola	Danieli Automation	f.cuzzola@dca.it
Hasan Esen	Denso	h.esen@denso-auto.de
Paul Houpt	GE Global Research Automation & Control Lab	houpt@ge.com
Zdeněk Hurák	Czech Technical University	hurak@fel.cvut.cz
Lalit K Mestha	Xerox Research Centre	Lalit.Mestha@xerox.com
Jeroen Ploegg	TNO Automotive	jeroen.ploeg@tno.nl

First virtual panel meeting

The first panel meeting took place on June 23, 2010. It was a teleconference meeting hosted and moderated by HPL, using Genesys infrastructure for audio and desktop applications. The participants were:

WIDE Consortium: A. Bemporad, (UNITN), V. Havlena (HPL), L. Baramov (HPL), M. Johansson (KTH), M. Heemels (TUE), V. Puig (UPC).

Industrial panel: J. Bay, J. Buckland, K. Butts, S. Di Cairano, F. Cuzzola, Z. Hurák, L. K. Mestha.

The agenda was as follows

1. Introduction of participants,   V. Havlena

2. WIDE overview,   A. Bemporad

3. WP2 – Wireless networking for control,   M. Johansson

4. WP3 – Multilayer distributed control and model management

                                    L. Baramov, A. Bemporad

5. WP 4 – Network-aware control and estimation   M. Heemels

6. WP 5 – Water network demo   V. Puig

7. Discussion

The presentations are publicly downloadable at

http://ist-wide.dii.unisi.it/index.php?p=virtualmeeting2010

After the meeting, feedback forms were distributed to the participants. Three forms and one e-mail note were received after the meeting; *their full content is included in the appendix of this document*. The feedback from the panel participants confirmed that WIDE approaches and results are of interest and innovative. The particular interest of the participants differ according to the industry: *Processing industry* representatives (see the response of F. Cuzzola) are interested mainly in distributed modeling and control of large-scale systems, while the representatives of the *automotive industry* showed an interest in wireless solutions.

F. Cuzzola (Danieli Automation) pointed at not particularly convincing applications, of those, the water-network case has relevance to process control, the others – meaning some examples illustrating decentralized control are not; however (unlike the water networks), they are not planned WIDE demo cases (and may be relevant to other areas as UAVs). Newly developed approaches to identification of large-scale systems would be of interest to him and can be considered for short-term application, in e.g., identifying tandem rolling mills in steel production.

Panel members from the automotive industry are interested in wireless solutions in vehicle-to-vehicle and vehicle-to-infrastructure communication. A concern was expressed by K. Butts (Toyota) on whether sufficiently dynamic scenarios were taken into account. These issues were actually considered in WIDE; even in the WP5 demo case, variable network topology is considered.

J. Bay (Assured Information Security, Inc.), raised the issue of robustness of wireless networks against malicious attacks. Including this into a control problem formulation is important for wireless control of infrastructures and should be considered. However, this is beyond WIDE scope, but it certainly is a highly interesting topic for future research.

Z. Hurak rose the issue on coordination between WP2 and WP4 work-packages. This has been explained to him.

Second virtual panel meeting

Second panel meeting took place on June 8, 2011. It was organized and moderated by HPL. unfortunately, due to irresolvable schedule conflicts we had a somewhat lower participation than the previous year. The participants were:

> **WIDE Consortium:** A. Bemporad, (UNITN), D. Barcelli (UNITN), L. Baramov (HPL), P. Trnka (HPL), M. Johansson (KTH), N. van de Wouw (TUE), V. Puig (UPC).
> **Industrial panel:** P. Brath, J. Buckland, K. Butts, S. Di Cairano, J. Ploeg.

The agenda was as follows

1. Meeting set-up

2. Introducing participants   L. Baramov

3. WP2 – Wireless networking for control   M. Johansson

4. WP3 – Modelling for Control/Distributed MPC   P. Trnka

5. WP3 – Decentralized Control   A. Bemporad

6. WP4 – Network-aware control and estimation   N. van de Wouw

7. WP5 – Water network demo – distributed solution for Barcelona water network and industrial platform prototype   P. Trnka

8. WP5 – Water network demo – evaluation and on-site test for wireless solutions   V. Puig

9. Discussion

The presentations are publicly downloadable at

http://ist-wide.dii.unisi.it/index.php?p=industrialmeeting2011

After the meeting, we received a feedback form from K. Butts that is included in the appendix.

Conclusions

The End-user panel was established in order to disseminate WIDE results within the industrial community, and to collect feedback that can be used for adjusting the working plan in mid-term of the project towards better exploitability, and for evaluating project results at the end of the project. This panel contained a number of distinguished researchers from a number of industries. These people were given detailed information on WIDE projects upon establishing the panel. Two virtual meetings were organized, where an overview on all work-packages was given by members of WIDE consortium. After the meeting, we received feedback from a subset of the industrial participants.

To summarize the feedback – WIDE research results were found innovative and of interest. The main results combining distributed control and wireless are expected to be applicable in the longer term. Some particular ideas, however, can be exploited in the shorter term. The focus differs according to the industry – processing industry finds results on large-scale modeling and distributed control more applicable. People from the automotive industry were more interested in the issues of wireless communication and control over networks, having mostly vehicle-to-vehicle and vehicle-to-infrastructure in mind. Participants of the meetings expressed their wish to be informed on WIDE results and further developments.

Appendix

End-user panel meeting survey form

Teleconference June 23, 1010

Name: Francesco Cuzzola
Affiliation: Danieli Automation SpA
E-mail: f.cuzzola@dca.it

Relevance of WIDE research plan

Please make some comments noting
- Relevance of the individual topics and of the project as a whole
- Which of the topics presented is relevant to your organization
    o WSN for distributed control,
    o distributed MPC and estimation,
    o modeling,
    o hierarchical control and optimization,
    o control over networks
- Can you compare WIDE to any similar project you are aware of?
- Are there specific topics that would fit in the general formulation of WIDE that were omitted in the plan?

Participant's remarks:

The project presents two main topics I found interesting
- Identification of distributed models for decision making support
- MPC for distributed systems.

Both these research efforts sounds quite useful for industry since they seem to face limitation of conventional controls towards real industrial control problems. Under these aspects WIDE presents particularly interesting innovative purposes never solved before.

The applications presented sound anyway quite far from real needs of industry: in particular applications for air traffic management does not sound to me realistic or useful whereas the application in water resource management sounds much more near to industry.

Approaches to the solution

Please make some comments noting
- Innovativeness of technical approaches to addressing problems defined in WIDE.
- Can you see any possibility of techniques and approaches being developed in WIDE in your organization or in your business
    o in present or in a short term?
    o in a long term

Participant's remarks:
To get a proper evaluation it is necessary to take into consideration realistic applications (see previous comment). In my opinion it is possible to consider also short term applications for metal industry in particular for what concerns the identification of complex distributed systems: this is the typical problem for tandem rolling mills for steel production.

Demonstration of the solution

Do you find the proposed demonstration case convincing for proving value of this research?

Participant's remarks:

No.

Technical results

Are you interested to get more details in any particular field?

Yes.

End-user panel meeting survey form

Teleconference June 23, 1010

Name: Ken Butts
Affiliation: Toyota Motor Engineering and Manufacturing, NA
E-mail: ken.butts@tema.toyota.com

Relevance of WIDE research plan

Please make some comments noting
  - Relevance of the individual topics and of the project as a whole

The project is important because such systems are becoming more prevalent. All of the technical sub-topics are important and interesting. However, the application example (water system) may not be so relevant to our automotive scenarios.
  - Which of the topics presented is relevant to your organization
    o WSN for distributed control,
    o distributed MPC and estimation,
    o modeling,
    o hierarchical control and optimization,
    o control over networks
  - Can you compare WIDE to any similar project you are aware of?

I imagine there will be strongly related projects once the US cyber-physical systems funding starts rolling though I can't cite any specific examples at this time.
  - Are there specific topics that would fit in the general formulation of WIDE that were omitted in the plan?

I am not sure whether you are considering highly dynamic scenarios where actors (nodes) are constantly entering and leaving the scene. I am thinking of vehicle-to-vehicle and vehicle-to-infrastructure coordinated driving in order to improve safety, reduce emissions / fuel consumption, and improve traffic flow.

Participant's remarks:

Approaches to the solution

Please make some comments noting
  - Innovativeness of technical approaches to addressing problems defined in WIDE.
  - Can you see any possibility of techniques and approaches being developed in WIDE in your organization or in your business
    o in present or in a short term?
    o in a long term

Yes in the long term, if we can verify that the system behaviour is correct and reliable. I believe there are significant regulatory / liability hurdles to address in this regard.

Participant's remarks:

Demonstration of the solution

Do you find the proposed demonstration case convincing for proving value of this research?

Not so much. The plant dynamics seem to be on a slow time-scale and the network configuration is essentially static.

Participant's remarks:

Technical results

Are you interested to get more details in any particular field?
Yes we are interested in all four technical sub-topics and the Matlab Toolboxes.

End-user panel meeting survey form

Teleconference June 23, 1010

Name: John Bay
Affiliation: Assured Information Security, Inc.
E-mail: john.bay@ieee.org

Relevance of WIDE research plan

Please make some comments noting
- Relevance of the individual topics and of the project as a whole
- Which of the topics presented is relevant to your organization
  o WSN for distributed control,
  o distributed MPC and estimation,
  o modeling,
  o hierarchical control and optimization,
  o control over networks
- Can you compare WIDE to any similar project you are aware of?
- Are there specific topics that would fit in the general formulation of WIDE that were omitted in the plan?

Participant's remarks:
It is clear that the participants have spent much attention to the modeling and control of the distributed networks, but only the obvious set of performance criteria were examined; that is, following of the set point and allowing for latency and dropped packets. However, the nature of distributed sensor networks presents problems that I find to be paramount in my field, such as Byzantine errors and security. These concerns transcend the first-order characteristics of control system performance. For example, malicious attackers will affect nodes in ways that are simply dropped packets, and common wireless network intrusion systems have the ability to implement rouge access points, perform denial-of-service attacks, and spoof data. From a control theoretic viewpoint, these might be accounted for in figures of robustness and error mitigation far beyond latency timing issues.   However, analytical modeling for control calculations is something I have not seen enough of. It is of special importance with application just such as the water distribution system used in WIDE: any public infrastructure control system should pay particular attention to fail-safety, tamper protection, and security.

Approaches to the solution

Please make some comments noting
- Innovativeness of technical approaches to addressing problems defined in WIDE.

- Can you see any possibility of techniques and approaches being developed in WIDE in your organization or in your business
    - in present or in a short term?
    - in a long term

Participant's remarks:

From my work with NATO/RTO and in other military domains, I have had a lot of exposure to distributed sensor networks, but these are largely only estimation problems (tracking, for example), and contained little analysis of the control problems. The WIDE presentations suggested to me the potential for such control applications, such as optimization of sensor resources (especially where bandwidth- or power-constrained), synchronization of diverse and dispersed assets, and secure dissemination of data. As discussed above, though, I am not sure that the modeling approach of the WIDE presenters accommodates these concerns. They could be an active area for future research.

Demonstration of the solution

Do you find the proposed demonstration case convincing for proving value of this research?

Participant's remarks:

Most prominently lacking are the robustness and security concerns discussed above.

Technical results

Are you interested to get more details in any particular field?

If any of the researchers have models for distributed secure systems, communications networks, or time-varying widely-distributed systems, I would be interested in learning more.

E-mail feedback on June 23, 2010 Panel meeting – Z. Hurák

Dear Dr. Baramov,

thank you for inviting me to the WIDE panel. In spite of the technical troubles during the teleconference I enjoyed the presentations. I only have one remark, hopefully you will tolerate that I put it directly here and not to the provided DOC form.

One of the workpackages (WP4) is focused on network-aware control. Another workpackage (WP2) is focused on control aware wireless network configuration. A question immediately pops up whether and how much the two workpackages actually collaborate. I can imagine that as an outcome of the control-oriented WP4 some new non-traditional requirements on the networking protocols can arise. Is the wireless networking oriented WP2 set such that this flow of ideas is realizable within the project? If I understand it correctly, the WP2 uses existing protocols for wireless communications and only considers their configurations, no modifications or even new protocols are planned within the project. Am I right? Anyway, I suggest that a coupling between the two workpackages is made more explicit in the future presentations. For instance, will the control algorithms invented by the WP4 produce some signals that would trigger some scheduling algorithms investigated by the WP2 so that some sort of total optimality is achieved?

To summarize, WIDE is an interesting project. I would be glad if invite me next time.

Best regards,
Zdenek Hurak

End-user panel meeting survey form

Teleconference June 8, 2011

Name: Ken Butts
Affiliation: Executive Engineer, Toyota Technical Center, Ann Arbor, MI, USA
E-mail: ken.butts@tema.toyota.com

Achieved results of WIDE and their relevance

Please make some comments noting
- Innovativeness of technical approaches to addressing problems defined in WIDE.
- Can you see any possibility of techniques and approaches being developed in WIDE in your organization or in your business
  - in present or in a short term?
  - in a long term

Participant's remarks:
In the short term, my colleagues and I will investigate your findings on the analysis and simulation of wireless network control systems, as well as the supporting tool-box. In the longer term, we may find applications for distributed model predictive control.

Demonstration of the solution

Do you find the proposed demonstration case convincing for proving value of this research?

Participant's remarks:

Yes. The research is important and relevant to our application area.

Technical results

Are you interested to get more details in any particular field?

Yes, based on our own study of the published results, we will probably ask for further clarification.