FP7 FUPOL PROJECT – INNOVATION IN POLICY SCIENCE

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Mathematically justified planning of policy is extremely important because any wrong decision can lead to serious consequences. It is no secret that mathematical modelling and other advanced analytical methods are rarely used for policy planning and decision impact forecasting because those require specific knowledge. The FP7 FUPOL project aims at a completely new approach to traditional policy analysis providing direct access for policy decision makers to domain uses cases modelling and verification on FUPOL Simulator and visualisation of the results in the form suitable for beneficiaries. Policy domain uses cases models are versatile, therefore architecture of the simulator must fit to the requirements of complexity and usability that determines involving heterogeneous agent-based and system dynamics simulation technologies and distributed simulation. The article deals with FUPOL approach in policy modelling and simulation, simulator designing, and sustainability assessment of provided technology. The FUPOL approach promotes simultaneously running of heterogeneous use case simulation models enhancing performance of simulation session. Belonging to open source spreads potential users' network thus reducing errors in simulation and also in policy decision making. Web services SOA based architecture enhances integration with other decision making and service tools.

UDC Number: 004.94, 338.2, **DOI:** 10.12955/cbup.2013.39

Keyword: Agent-based simulation, policy modelling, sustainability, FUPOL

Introduction

Policy modelling as the object of research is versatile and complex. FP7 FUPOL project (see www.fupol.eu) aims at a new approach to traditional policy modelling. Major innovations like multichannel social computing and crowd sourcing used for data gathering change the way how politicians communicate with citizens and enterprises, and make decisions.

The simulation and visualisation tools assist to municipalities and policy makers in the whole policy life cycle and allow avoiding of voluntary and wrong decisions. The set of policy domains (Sonntagbauer, 2012; Piera, 2012) of FUPOL involves community facilities (area design, open space), urban segregation and economics, edge land industrialization, sustainable tourism and other.

Each of them comprises many use cases which must be modelled in conformity with the comprehensive approach used in FUPOL project.

FUPOL Policy Modelling and Simulation Methodology – Way to Avoid Mistakes

The FUPOL policy modelling platform consists of joined work packages, which collaboration is aimed to creating the new possibilities for policy domain specialists related with forecasting of potential decision impact. It is carried out introducing modern supporting tools as semantic search, simulation and visualisation. Policy domains and use cases identification is carried out together with beneficiaries (Buil, 2012). In FUPOL case those are big European cities. Policy modelling work package is responsible for policy use case models designing and verification, which is carried out using Coloured Petri Networks (CPN) and Fuzzy Cognitive Maps (FCM) (Sonntagbauer, 2012). The FCMs, CPNs and Agent-Based Modelling/Multi-Agent Systems (ABM/MAS) approaches are combined to achieve certain level of transparency by describing the causal models as a set of behaviour rules. The rules are also documented in a natural language for beneficiaries and simulator software designers' needs. If for particular domain use case implementation system dynamics (SD) simulation is advisable then the analytical equations are used as the form of specification.

CPNs and FCMs are used to define the agents' behaviour and, in the case of CPNs, also to validate the rules by studying their state space reach ability. Verified policy model use case specifications in transparent, understandable and formalized form (agent specification, agent interaction specification, time specification, flow model specification, system dynamics model, interoperability and data exchange specification, drivers, boundary conditions, quantitative parameters, input data sources and links, and other notes) with added explanations in natural language are transferred to Simulation work package for FUPOL Simulator software designing provided for use cases simulation models running. As a result of the simulation software running, the simulation data generated are analyzed using data mining approach ANFIS (Xue, 2006) to refine the final FCM relations and their weights in policy uses case model. Beneficiaries also can use visualised FCM to better understand the causal effects.

Validation of the simulation model developed is performed in three steps. First step is aimed to beneficiaries' acceptance recognition when different experts participate in analysing the simulation results reviewing different scenarios and boundaries conditions to accept/reject the results obtained. Academic validation is aimed to clarify if the different reachable states that could be obtained in a real context negotiation for the deployment of an urban policy can be generated by the rules codified in the ABM/MAS environment. The third step is statistical validation of the policy use case simulation model using Kolmogorov-Smirnov tests to approve the confidence of the simulation results.

The methodology described above determines the requirements to the FUPOL Simulator implementation. Because the FUPOL Simulator is a part of FUPOL software it also must comply (with some constraints) with the interoperability requirements accepted in FUPOL software environment.

Heterogeneous Multi-Level Architecture on Web Services Based FUPOL Simulator

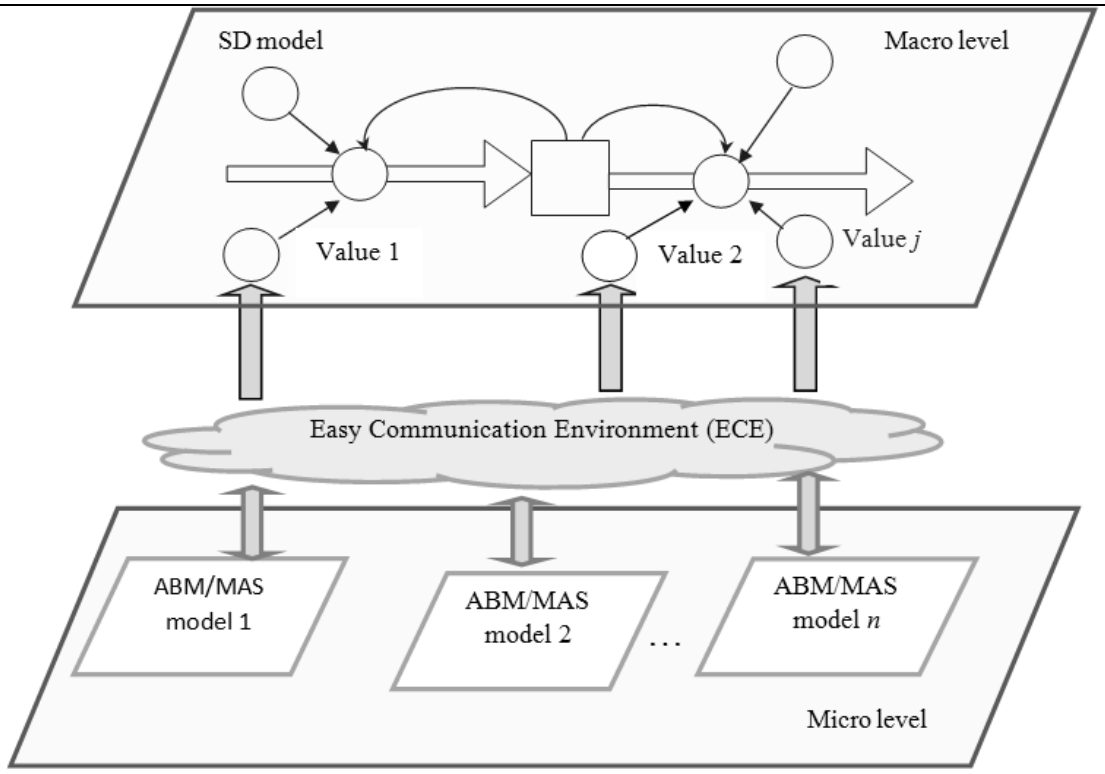
The FUPOL Simulator is responsible for running the simulation of policy use case models elaborated in conformity with policy use case modelling methodology.

The simulation is ensured at two levels: micro and macro simulation (see Figure 1). At the micro level ABM/MAS operations related to versatile and small basic components interaction and forecasting of the interaction results are carried out. Using micro simulation, for example, Land Use Category

Changes (LUCC) cases are implemented. At the macro level the SD simulation is used for forecasting of continuing changes, for example, demography. Then the micro level is the data source for the macro simulation model.

Modelling of policy domain use case model determines implementation the set of possible scenarios. It means that $UseCaseModel_m = \bigcup_{j=1}^{J} \langle Sc_j^m \rangle$, where Sc^m is the set of scenarios aimed to implementation of $UseCaseModel_m$, but J is the total amount of possible scenarios of use case m.

Figure 1: ABM and SD simulation models integration in FUPOL Simulator preliminary architecture



Source: Authors

However, each Sc_j^m comprises implementation the set of tasks $\langle T^m \rangle$. Each task can be realised as running of single or the set of simulation models $\langle ABM/MAS, SD \rangle$ creating homogeneous or heterogeneous queue of running simulations. It means that each $t_i^m = \bigcup_{n=1}^{N} \bigcup_{k=1}^{K} (ABM/MAS_n, SD_k)$, where N and K is total amount of simulation models joined for t_i^m task implementation.

If the scenario requests for simultaneous interoperability the set of models then Easy Communication Environment (ECE) (Silins, 2010) is ensured for distributed simulation implementation.

ECE is communication mechanism provided for data exchange among simulation tools and models. The base is a reduced High Level Architecture (HLA) (Perumalla, 2011) exchange mechanism based

on principles of broadcasting. One of the main statements of ECE is simplicity of use to promote designing of distributed simulation models for domain specialists who have no specific knowledge in programming.

FUPOL Simulator operation is based on Web services interoperability using Service Oriented Architecture (SOA). The statistical and spatial data exchange with other FUPOL software parts is ensured by Enterprise Service Bus (ESB) (see www.mulesoft.com). Visualisation services also use ESB to access the simulation data. The FUPOL Simulator GUI ensures direct access to the simulation facilities for policy decision makers worked on potential decisions impact assessment.

For verification and validation of FUPOL Simulator the LUCC use case was selected allowing checking architectural solutions, implementation tools, interoperability with FUPOL Core platform, spatial and statistical data processing possibilities, GUI designing, and testing of data visualisation features. LUCC was selected because land use is a basement for further use cases simulations. The user had possibilities to visualise simulation region map with overlaying CORINE (Corine, 2012) land-use categories map. On the simulation desktop could be drawn red lines (polygons) to limit LUCC features. In legend could be indicated influence (weight) of each land-use category in simulation session. Vicinity of changes and simulation duration also were defined by user. After simulation session all the intermediate and final spatial and statistical results were stored and visualised.

The FUPOL Simulator LUCC use case simulation results were compared with Metronamica (Linke, 2008) and MOLAND (JRC, 2013) output series. Statistical Mann-Whitney and Wilcox tests given similar results approving that with the confidence alpha 0.95 the series are paired, and therefore FUPOL Simulator LUCC application use case can be considered as validated.

However, the question how sustainable is this innovation in policy science and analysis remains.

Sustainability of Innovation – Warranties for Long-time Right Decision Making in Policy Planning

Prior to every development of new technology or innovative service, the stakeholders want to be sure that the proposed technology will attract long-term users and create positive output and/or outcome according to the purpose of the technology and initial intentions of its developers (financial, social, etc). In other words – they want the technology to be sustainable. So far previous studies focus separately on psychological or socio-economical aspects of technology acceptance (Technology acceptance model (Davis, 1989), Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, 2003), Expectation-Confirmation Theory (Bhattacherjee, 2001), specifically on success of information systems (Petter, 2008), on management systems, or diffusion on innovations (Roggers, 2003) on the whole.

Generally speaking, sustainability is the capacity to endure. But it differs from viability, as it includes additional meaning. Being one of the most discussed topics the terms “sustainable” and “sustainability” have also gained many meanings and conceptual interpretations. Different definitions range over such concepts as resource use, long-term existence, responsible management, in different application situations they have environmental, economic and social dimensions. The sustainability of technology is mostly analyzed within the context of environmental issues that the technology itself creates. Speaking about sustainable technology, one refers to environmentally, socially and

economically responsible technology that promotes or creates some kind of benefits. Only a few authors broaden the understanding of sustainability of technology. But it is important to ask what needs to be sustained. Specifically, is it the technology, the environment around it or the capabilities enabled or affected by that technology?

The sustainability of innovations is also a matter of the quality of decision making process in policy planning. Nowadays more and more decisions are based on socio-technical solutions – large scale, distributed software and simulation models. Therefore the sustainability of these solutions is important both for the developers as well as potential users.

The Integrated Acceptance and Sustainability Assessment Model (IASAM) introduces a new approach for evaluation of technologies, by combining socio-economical aspects and socio-technical characteristics of technology development and exploitation. It addresses the question, how to evaluate technology acceptance and sustainability at any chosen point of time of the technology life cycle and forecast the chances of technology to attract users and achieve the aims of its developers.

IASAM consists of four groups of factors that have an impact on integrated technology acceptance and sustainability: Management – successful management of every asset; Quality of technology – quality of the product, quality of production, including supporting services; Acceptance and economical context; Domain development – the impact of domain and societal development.

Acceptance is measured using UTAUT methodology and other factors are evaluated using a set of pre-defined criteria. In short, IASAM suggests integrating the UTAUT approach for acceptance evaluation with other socio-technical factors thus framing united multi-level framework for technology assessment. The model serves as a framework for successful technology development and assessment. By using SD the model allows its users to monitor the variation of the IASAM index over time.

Technically IASAM is implemented using the SD simulation environment Stella (see www.iseesysems.com) or InsightMaker (see www.insightmaker.com).

FUPOL project proposes a comprehensive new governance model to support the policy design and implementation lifecycle. It aims at reducing the complexity through a comprehensive policy spiral design lifecycle approach deemed appropriate for complex societal problems. Therefore this project itself aims at promoting high quality decision making in policy planning process. It means that the modelling and simulation approach developed within this project have to meet the criteria of IASAM.

Speaking specifically about the FUPOL Simulator, it can be concluded that this product does meet the majority of IASAM criteria. This paper will give just insights about the factors that have impact on IASAM criteria:

- regarding the management of assets (resources and staff), strategically planning and political/legislative support, the broader setting of FUPOL project should be evaluated. Namely, it is funded under EU FP7 programme and it means strict project management, and control procedures ensuring also that the IASAM Management factors group criteria are met;
- also the quality of technology relates to the management of FUPOL project. For example, it defines requirements for documentation, and it defines strict production timeline, etc. All these procedures ensure higher score for IASAM criteria;
- since FUPOL project involves co-operative evaluation of the FUPOL Simulator in international environment that means greater awareness of policy domain use cases simulation models development processes and less criticism after the development of technology.

At the same time user acceptance according to IASAM framework is evaluated using UTAUT methodology. That means that no estimated variables are available at this point of time and preliminary assessment approved that FUPOL innovation in policy analysis can be considered as sustainable.

Conclusion

Policy modelling is complex task due to huge amount of important influencing factors comprised. Mostly policy decision makers are not familiar with modern modelling technologies, mathematics and complex software tools. Therefore, great amount of decisions are intuitive, voluntary and wrong. To change the situation under the framework of FP7 FUPOL project is intended to develop new approach in policy analysis and decisions making which is based on innovative solutions use comprising advanced semantic search methods, data mining, and simulation and visualising technologies granting possibilities for policy decision makers to verify their decisions before introduction in real life.

The designing approach promotes that simulator ensures simultaneously running of heterogeneous use case simulation models enhancing performance of simulation session. Belonging to open source and freeware software group, and granting multilingual support spread potential users' network reducing amount of errors in simulation software and also in policy decision making. On Web services and SOA based architecture enhances integration with other decision making and service tools.

The policy modelling and simulation approach described in the article will be further developed under the FP7 FUPOL project framework introducing relationships development between simulation model and FCM, where FCM will be used for simulation driver's weight assessment and correction. The sustainability research of the approach will be adjusted and updated.

Acknowledgement

The FUPOL Simulator described above has been developed under the framework of FP7-ICT-2011-7 IP project FUPOL No. 287119 (2011-2014) "Future Policy Modelling".

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