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A behavioural analysis approach for the 'City of Things'

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***Abstract*: The 'City of Things' testbed located in the (smart) city of Antwerp provides new opportunities for conducting Internet of Things (IoT)-based experiments on a large scale. The paper proposes a three-part Modular Behavioural Analysis Approach (MBAA) to design large scale user experiments within the testbed, which makes it possible to measure objectively, contextualised and thus realistic user behaviour in real-time.**

I. INTRODUCTION

In the past years, the concept of 'smart cities' has become somewhat of an established concept within a policy setting, but increasingly in academia as well, especially in urban development. Smart cities can be understood as information and communication technology-enabled urban environment fostering e.g. citizen well-being and living, environmental sustainability, governance efficiency, a flourishing economy, and improved mobility [1]-[2].

Currently we can detect an interest in and adoption of 'Internet of Things' (IoT) technologies, and the possibilities they offer to integrate real-time sensor data in a city-context. However, such smart city set-ups tend to be limited to isolated small-scale experiments. Latré et al. (2016) introduce with 'City of Things' (COT) - a means to advance the current smart city vision by creating a multi-technology testbed which is able to integrate real large-scale deployments [3]. The testbed, based in Antwerp, Belgium, is designed to address smart city challenges at network, data and user level. It is the user level that this paper wishes to address.

At user level in a COT environment, the digital smart services offered to users can be both non-IoT based (i.e. applications) or IoT-based (i.e. sensor data). These can be used in insolation or in combination for example by using dedicated wearables, sensor stations and smartphones. As a result, real-life behaviour and its context becomes objectively measurable – and thus systematically analysable. This makes it not only possible to study individuals' behaviour and underlying motivations in a smart city context (e.g. pattern sand motivations of bike usage), but also to bring behavioural analysis research to a new level, i.e. to study attempts to change individuals' behaviour through specific interventions. Goals of such interventions in a smart city context can foster biking or car-sharing, reduce waste or encourage sustainable food consumption.

While the usefulness of a behavioural analysis approach in a smart city context is obvious, a comprehensive approach how to conceptualise, design, and apply behavioural research in a smart city context is not developed yet. Hence the paper proposes a modular behavioural analysis approach (MBAA) suitable for the COT testbed.

In the following Sections, an overview of the proposed approach is presented and examples of actual use case of COT projects, which can benefit from the approach, are briefly outlined.

II. THE MODULAR BEHAVIOURAL ANALYSIS APPROACH (MBAA)

The proposed Modular Behavioural Analysis Approach (MBAA) consists of three Parts: *(A)* the (theoretical) conceptualisation of the planned behavioural analysis in order to identify purpose and research focus of the planned behavioural analysis, *(B)* the (empirical) design of the behavioural analysis providing a step-by-step approach to set up behavioural experiments, and *(C)* the (practical) application of the analysis to facilitate the valorisation of the results of the behavioural research.

A. Conceptualising behavioural analysis

Behavioural analysis is highly interdisciplinary drawing on fields as diverse as economics, and clinical and social psychology. Due to the complexity often associated with behaviour, a universal model does not exist. Instead, an abundance of theories tailored towards specific needs can be found in existing literatures [4]. Fig. 1 aims to provide a means for developing behavioural analysis approaches by mapping the research's focal interests and purpose. The figure is modular in the sense, that the prevailing research can, but does not need to, address all aspects of behavioural analysis; rather it can target a specific focus e.g. motivations and awareness, behavioural actions and patterns or the process of change per se.

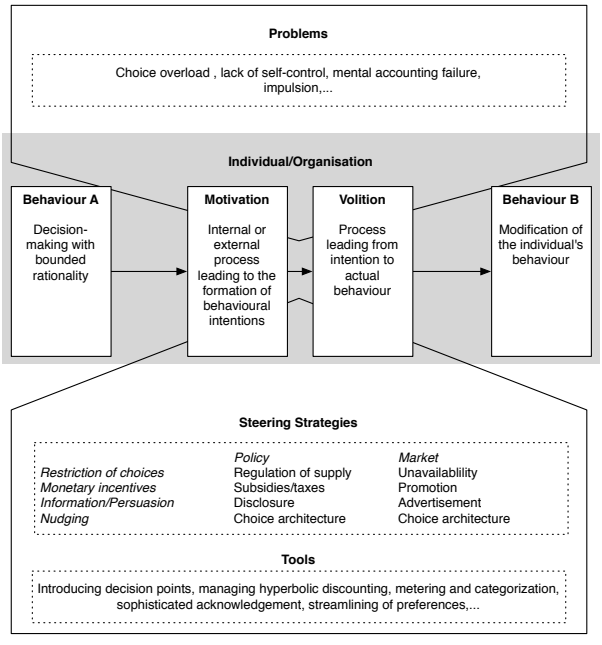

FIGURE 1: BEHAVIOURAL ANALYSIS APPROACH. PROCESS OF BEHAVIOURAL CHANGE AND POSSIBLE INTERVENTIONS.

B. Designing behavioural analysis

The MBAA relies mainly on field experiments, more specifically on large scale randomised control trials (RCTs) i.e. A/B-testing. Classical lab experiments have the advantage of high control due to precisely isolated causes and effects, which is especially valuable in early stages of research i.e. theory development. Field experiments, however, have the advantage of being able to capture real-word behaviour and acknowledge noisiness and context, each of which is integral in smart city context. They can include a large number of conditions i.e. various factors, and are especially valuable in testing the actual effect of behavioural interventions. The following 6-step design guide helps to create the experimental set-up of large scale RCTs:

Step 1: Randomization

Identification of factors i.e. causes/effects (A/B) to be measured in each use case and the prevailing intervention (dependent and independent variable and treatment), e.g. no comparison with peers (A), comparison with peers (B) (cause) on energy consumption (effect), change of App interface (treatment).

Step 2: Conditions

Identification of the level(s) of each factor i.e. possible influencing factors (mediating and moderating variables), e.g. comparison with community/individuals with similar profile and e.g. age or gender.

Step 3: Set-up

Determination of number of required units for robust results and definition of measurement period and duration of A and B situation.

Step 4: Trial

Assignment of the conditions and introduction of the treatments, data collection at point A and B as defined.

Step 5: Data analysis

Analysis of Variance (ANOVA), regression analysis via SPSS or more advanced programs (big data processing).

Step 6: Data visualization

Comprehensive display of the results.

C. Applying behavioural analysis

As suggested above, the strength of large-scale RCT is their possibility to assess real-world behaviour. While the introduced 6-step design forms the core of RCTs, applying RCTs to real-world business or policy problems requires an embedment of this core design task in a larger contextual procedure. This makes it possible to explicitly test business or policy interventions in a smart city context. For this purpose, the previously described conceptualization *(A)* and design steps *(B)* have to be integrated in a macro-framework for valorisation. Three tracks can be identified.

Track 1: Behavioural consciousness

This most basic track focuses on raising individuals' or organizations' awareness for a certain subject matter and explores their intrinsic and possible applicable extrinsic motivations.

Track 2: Behavioural action

The second possible track is concerned with the analysis of individuals' or organizations' behaviour per se, targeting volition and behavioural patterns

Track 3: Behavioural change

The third, most complex track is concerned with the actual process of changing behaviour and explores strategies and tools to facilitate such a change as well as the problems inspiring a behavioural change.

While each track follows the same valorisation process, each instance is tailored to the purpose of the valorisation. The valorisation process begins in each case with the identification of a problem to be solved (*(i) Problem identification*). Depending on the track, this could involve the need to raise attention for a certain smart city concern, an analysis of individuals' adoption of smart city applications or the comparison of policy or business interventions and their impact on individuals' behaviour. This step blends with the examination of the RCTs' theoretical foundation and the research's state of the art as described in *(A)* (*(ii) Conceptualization*). It follows a development of use cases corresponding with the focus of the chosen track and the development of hypotheses to be tested (*(iii) Translation*). Subsequently, prerequisites such as infrastructure, application interface and their development have to be defined and the access to a recruited panel of participants has to be organised. Moreover, ethical aspects must be considered, especially when following Track 3 (*(iv) Foundation*). Then, as described in *(B),* measures from the use cases are derived. In some Track 1 and 2 cases, this might rely on, or be informed by, traditional qualitative approaches, while Track 3 is heavily based on A/B-testing (*(v) Experimentation*). Finally, depending on the track, strategies for influencing behavioural consciousness can be proposed, behavioural patterns can be mapped and understood, or the impact of the examined business or policy interventions can be determined (*(vi) Recommendation*).

III. EXAMPLES

The application of the introduced MBAA can be demonstrated in the context of one emerging COT project. In addition to the current bPost case in COT [3], we are building with IPRAS project (Incentive-Based Personalised Recommendation As a Stimulus) a case that will use both traditional data collection methods (surveys), in addition to real-time experience sampling techniques for context measurement (Track 1). In combination with a living lab methodology for innovation co-creation, the use case aims to develop a persuasive technology, through which behaviour change interventions can be tested (Track 2) and evaluated (Track 3). Note that a minimum of three large scale experiments are currently being designed with several cities in Flanders (within the context of the Chair Smart Cities at the Vrije Universiteit Brussel and the Smart Flanders initiative).

IV. CONCLUSION

The Internet of Things (IoT)-enabled smart city testbed 'City of Things' (COT) provides new opportunities related to real-time testing in a real-life context on network, data, and user level. This paper proposes a first, initial approach to enable user analysis in the testbed. The introduced Modular Behavioural Analysis Approach (MBAA) consists of three parts facilitating the conceptualisation,

design, and valorisation of behavioural analysis in a smart city context.

REFERENCES

[1] Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., & Meijers, E. (2007): *Smart cities: Ranking of European medium sized cities,* Vienna: University of Technology.

[2] Dameri, R. P. (2013): Searching for smart city definition: A comprehensive proposal, *Journal of Computers and Technology,* Vol. 11, No. 5, 2544-2551.

[3] Latré, S., Leroux, P., Coenen, T., Braem, B., Ballon, P. & Demeester, P. (2016). City of Things: an integrated and multi-technology testbed for IoT smart city experiment, Smart Cities Conference (ISC2), *IEEE International,* 1-8

[4] Soman, D. (2015): *The last mile: Creating social and economic value from behavioural insights*, Toronto: Rotman-utp Publishing.