Team One2tribe Lab: Using Machine Learning to Manage Work-Related Stress

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***Abstract*— According to World Health Organization more than 40 million people in Europe are affected by stress at work. Worldwide, the cost of mental health problems is amounting to hundreds of billions of dollars annually. Work-related stress leads to heart diseases and depression. From psychological point of view, occupational mental strain is caused by job demands that cannot be fulfilled by a worker due to her/his lack of knowledge, abilities and control. We are building Machine Learning solution that will cope with that problem by building daily work "motivational" scenarios for high-strain job workers. We assume that if we succeed, our technology will impact work planning and scheduling in the organizations, leading to more personal, human-centric management. By motivational scenarios we mean task-reward sequences (i.e. scenarios that include tasks and reinforcement delivered when task is done).**

Keywords — Mental Health; Occupational Health; Psychology; Reinforcement Learning; Model Selection and Structure Learning; Decision Processes; Gamification; Game Theory

I. Problem Statement

According to World Health Organization (WHO) nearly one in three Europe's workers (more than 40 million people), report that they are affected by stress at work. The cost of mental health problems related to occupational strain in the first 15 European Union countries was estimated to be on average between 3% and 4% of gross national product, amounting €265 billion annually [1]. The health impact of stress is devastating. Substantive studies show that the mental strain at work may lead to heart diseases, musculoskeletal disorders and depression. The cardiovascular disease is leading cause of death in developed countries [2] and key risk factor for this disease is identified to be stress [1]. The losses are not only measured in billions of euro and dollars, but are a matter of something less tangible, but far more valuable - human lives.

What are the causes for the work-related stress? In general, "work-related stress is the response people may have when presented with work demands and pressures that are not matched to their knowledge and abilities and which challenge their ability to cope". [3] This fact is a foundation for Karasek's job demands-control model [4,5] – see Fig 1.

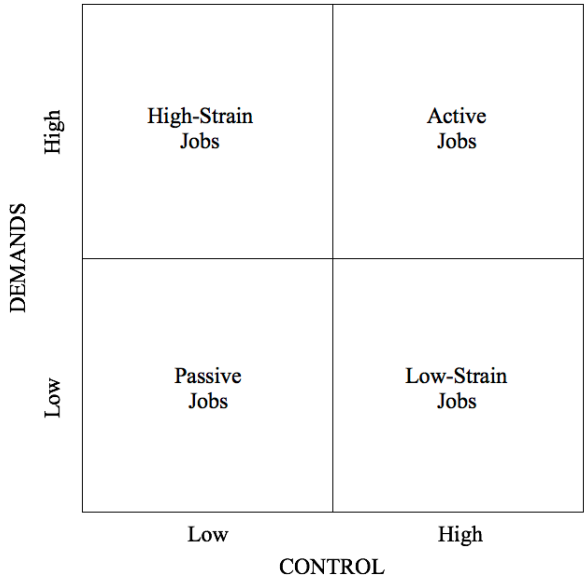

Fig. 1 Karasek's demands-control model

The Fig 1 shows four work environments:

- High-strain jobs (demands are high, control is limited) – these kinds of occupation are characterized by high risk of mental strain and can be found in many sectors (financial, insurance, shared services etc.).
- Active jobs (demands are high, control is high) – these kinds of jobs are similar to high-strain jobs in terms of demands, but "increased energy arousal is appropriately channeled through active, empowered problem solving (i.e. high job control)" [6]. The ability to learn new skills, and act according to the demands, reduce work-related stress.
- Low-strain jobs (demands are low, control is high) – these are jobs where the work-stress is usually low, and risk of psychical illness is not significant.
- Passive jobs (demands are low, control is low) – Karasek's research [5] shows, that these are jobs that create "an average level of psychological strain and illness risk"

Passive jobs and low-strain jobs are out of scope of our problem statement. They neither generate significant work-related stress nor require special managerial approach. We perceive that our key problem lies in transition from high-strain to active jobs.

This kind of transition requires three kinds of changes:

- Changes in how job-control is done (matching workers skills and abilities with challenges, providing sufficient work-related knowledge, shaping new behaviors, taking employee stress level into consideration during task planning)
- Changes in how job-demands are stated (decomposing large challenges into small, manageable pieces of work that can be supported by control mechanisms and causes less mental strain)
- Changes in motivation mechanisms (how tasks are rewarded, based on their demands and results)

The latest is the key part of the process. The reward schedules are fundamental mechanisms of behavioral psychology and the basic for operational conditioning – a process for learning new behaviors, that associates' action with consequences. From managerial point of view the reward is also a signal that specific task was completed and can be used to denote challenge result (i.e. percentage of success) in a way easy to understand by the users (employee).

By using appropriate reinforcement mechanisms, we offer:

- For employees - more control of the process (i.e. instant gratification works as instant feedback) and the ability to learn new behaviors (learned behaviors / habits are characterized with lower mental strain)
- For managers – the means to define demands in the effective way (as challenges that are defined as tasks with rewards for task partial or total completion)

From this point of view, the problem we are trying to solve is to support managing large scale teams of workers in a way that it will provide at the same time:

- Workforce well-being (minimizing negative impact on health and mental conditions). The stress can be perceived as a cost in provided economy.
- Economic efficiency (meeting the demands and goals set by company leaders with the lowest possible cost – including negative personal costs related with the stress and reward costs)

II. Goal Statement and High Level Description (Idea) of Solution

Our goal is to find optimal scenario (schedule of tasks specifying demands and rewards) for each individual. By "optimal" we mean:

- Providing best (maximal) possible business outcome (this usually means reaching the business goal with the best possible effort - reward ratio)
- Providing minimal possible negative impact on individual life (minimizing stress, reducing work burnout)

Our solution is the system that provides adaptive scenario (motivational scenario, referenced later as MS) that have the ability to adjust themselves to:

- Employee characteristics (we can define different scenarios for different segments of users)
- Actual user actions/results (in real-time the user may be given alternative tasks depending on her/his current performance and stress level)

MS is based on Directed Acyclic Graph (DAG), which nodes are:

- Challenges (tasks with rewards, including operational tasks – for example customer call and knowledge tasks – quizzes and tests)
- Decision points (where a user decides what he would like to do in a given moment)
- Questionnaires (user provides us with data, like answers to the questions of PSS-10, perceived stress scale questionnaire)

The edges of the graph are representing transitions between nodes. During execution of scenario next node may be selected using two kinds of rules:

- Result of current challenge/node (i.e. finishing just 30% of challenge may lead the user to node A, whereas finishing 100% of challenge may lead the user to node B).
- Aggregated result of the all challenges (preceding nodes) in the path across MS. For example, if so far user scored just 30% of total scenario score (all challenges from scenario beginning) he may be directed to a specific path of execution. This allows us to adjust user scenario execution to overall business goal of the scenario (i.e. number of calls in call-center per day or week).
- Aggregated stress measure (measurement can be defined as a specific node – one of the actions being the part of MS)

Graph structure provides the means for self-adaptation of the scenario. Depending on user performance (in the last challenge or aggregated from scenario start) and stress next actions may be selected. So, the same scenario may be executed differently depending on user's performance.

The diagram below shows the idea of MS structure (see Fig 2), sample scenarios are also presented at the end of report (see Fig 3)

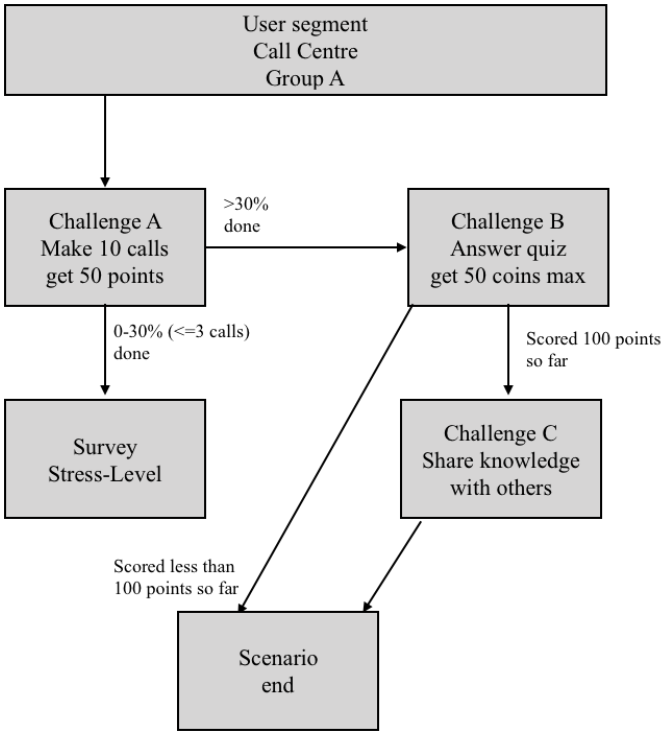

Fig. 2 Example structure of Motivational Scenario (MS)

During previous phases of our system development we planned for the scenarios to be created fully automatically from the historical behavioral data. During real life tests this approach proved to be ineffective and impossible (the results does not create a well-founded scenarios). Current idea focuses on optimization of MS'es defined by the experts and on graph structure of scenario (providing means for work demands / control adaptation).

The System works as follows:

A. *Experts create initial Motivational Scenario for the selected user segment*

The expert selects user group for which the scenario is defined. Group may be defined explicitly or as a result of another scenario execution (we will refer to this later). For the given group the scenario may be designed visually (with the ability to select reinforcement level for each challenge). Suitable economy mechanisms are implemented for the user to define the overall limits for reinforcement (reward budgets, not discussed in this document).

B. *Users are executing the scenario and execution data is collected*

Users from the given group are executing the scenario. Please note that finishing scenario does not mean achieving goal by the user. Also – some executions may remain unfinished (users may leave the scenario due to lack of skills, abilities or stress). The data collected from scenario execution include:

- Selected paths (scenario may contain decision points for the users – for example they may select mode demanding challenge over some simpler activity)
- Business results (challenges results)
- Stress level (measured using questionnaires or external tools)

C. *Scenario is optimized using collected data*

The collected data is used to optimize the scenario using three approaches:

- Scenario is updated bottom-up to provide better business results or reduce stress. Updates focuses on reinforcement levels (for the paths we would like to reinforce) and transition conditions (thresholds). During the process nodes that are not visited by the users can be also removed from the scenario.
- Creating new user segments – for some employees/users updating scenario may be "not-enough" (stress level may be too high at some point, or business results may fall below expectations). In this case we may use the scenario to determine this group and create new scenario for them (this new group is the result of the scenario – i.e. MS works as a classification algorithm).

The above approach changes the way, the work is being planned and controlled for large organizations are repetitive tasks (contact-centers, sales networks, distribution networks).

- We provide the tools that are adjusting working scenarios for individual (actual) performance of the employee and her/his stress level. The managers can define scope of work and targets in a human centric way.
- The scenarios can be incrementally optimized based on collected execution data (machine learning)
- The scenarios can be disrupted (defined completely anew) for discovered new user segments (profiles) – i.e. if for some user group we are exceeding aggregated stress level, manager can create new group and define new scenario for it (this scenario can again be optimized by the system).

We will discuss this later in the Technology Impact section of the current report.

III. The problem for ESGI

The technologies we are developing include:

A. *Motivational Scenarios engine*

Engine is based on the adaptive scenario model (described earlier in this report) based on DAG (Directed Acyclic Graph) providing topological ordering for challenges and decision points. The challenges are executed in provided order by Tribeware Motivational Platform (our own technology). The execution data (paths chosen by users, rewards delivered) are stored in in-memory database (Mongo DB). The engine also

contains user segmentation mechanisms (the possibility of splitting whole user population into segments and sub-segments volitionally or by the classification algorithm). This part of technology is currently operating in production environment for our team customers and is based on real world-data (see Fig 3 at the end of document).

Motivational Scenario as a structure can be perceived as a specific form of decision tree and is used for user's classification based on their choices or performance.

B. Optimization module (ESGI problem)

Training data is collected using users' actions and used to update the motivational scenario. The goal of the optimization engine is to minimize employee stress level, by updating scenarios. The key problem here is to predict stress level earlier (measurement of stress is not a problem)

We are thinking about two approaches:

- Markov Decision Processes (MDP) – that can model up user's behavior in our system (MDP's are built of states, transitions, rewards etc.). The stress level in the model is a punishment (negative reward) [10]
- Active Inference / Free Energy Principle (by K.Friston) – which is a probabilistic model of how human brain works (simplification) [9]

To not limit the creativity at the ESGI sessions we do not suggest any approach.

EXAMPLE

Fig 3. shows sample execution scenarios for two real world cases. It shows how the motivation scenario is visually defined and how users are traversing it.

Tables data shows number of users that visited each node of the graph (percentage of users visiting nodes is shown on diagram).

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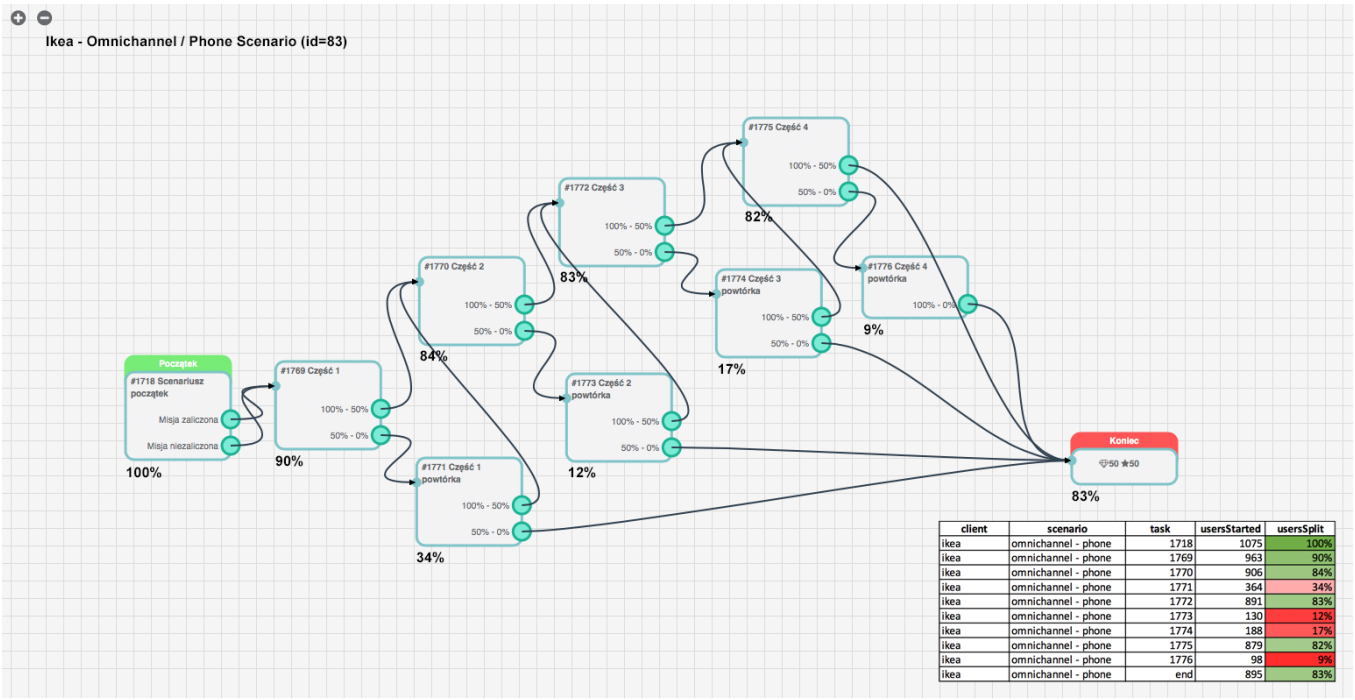
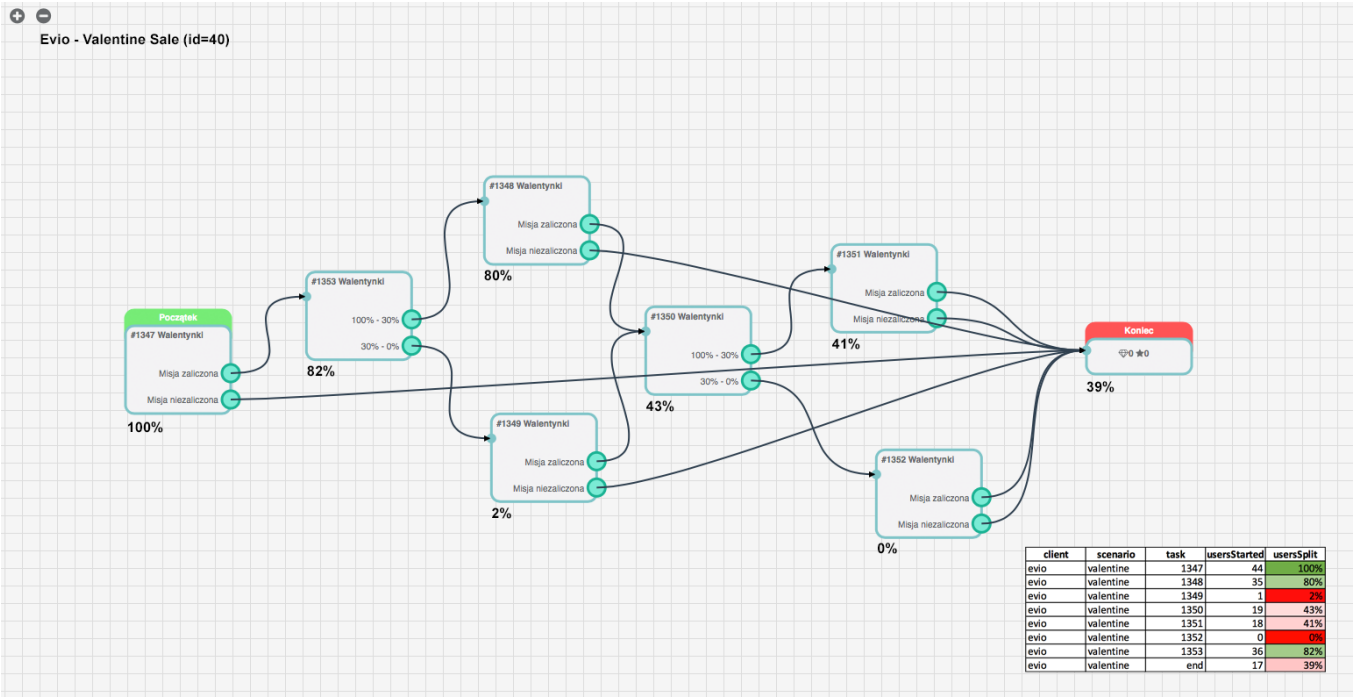


client	scenario	task	usersStarted	usersSplit
ikea	omnichannel - phone	1718	1075	100%
ikea	omnichannel - phone	1769	963	90%
ikea	omnichannel - phone	1770	906	84%
ikea	omnichannel - phone	1771	364	34%
ikea	omnichannel - phone	1772	891	83%
ikea	omnichannel - phone	1773	130	12%
ikea	omnichannel - phone	1774	188	17%
ikea	omnichannel - phone	1775	879	82%
ikea	omnichannel - phone	1776	98	9%
ikea	omnichannel - phone	end	895	83%



client	scenario	task	usersStarted	usersSplit
evio	valentine	1347	44	100%
evio	valentine	1348	35	80%
evio	valentine	1349	1	2%
evio	valentine	1350	19	43%
evio	valentine	1351	18	41%
evio	valentine	1352	0	0%
evio	valentine	1353	36	82%
evio	valentine	end	17	39%

Fig. 3 Execution example for Motivation Scenario