A modeling method for strategic design of semantic digital nudging

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Abstract

There's a growing interest in optimizing User Interface (UI) design to better align with organizational strategies and facilitate improved guidance of users towards specific options in a choice architecture, a kind of user behavior influencing known as "digital nudging". The paper reports on a Design Science Research project introducing a domain-specific modeling method to integrate digital nudging strategies with User Experience (UX) and feature portfolio design.

This paper proposes Semantic Digital Nudging as a modeling method that semantically enriches Digital Nudges implemented in UX workflows by linking to target product features. This is deployed as a visual tool that embeds properties which can be queried to assess the friction certain nudges cause on User Experience and to maintain an inventory of by-design nudges. Linking the procedural knowledge in UI usage flows with product features and the nudging patterns makes this a multi-perspective domain-specific modeling approach that can help businesses to plan the layout of user choices, or help the user make more sustainable choices by increasing salience of healthier alternatives.

Keywords

Human-Computer Interaction, Digital Nudging, User Experience, Agile Modeling Method Engineering

1. Introduction

E-Commerce retailers have total control over how the user interacts with merchandise (User Experience) and User Interface presentation. Digital Nudging is the practice of influencing consumer behavior in the context of choice. Organizations can strategically design websites for this by applying biases in human decision making [1]. Concurrent priming is a form of what Information Systems researchers call *digital nudging*. The stimulus is overtly presented on the same screen simultaneously with the focal point of interest. The user is aware of the stimulus, but not its intent. *Semantic priming* [2] shows an option and presents as stimuli its characteristics that are memorized by the user. User's cognition compares characteristics to assess which variant to opt for and how much to pay for the focal product (concept).

Having found this convergence point between semantic priming and digital nudging, we propose *Semantic Digital Nudging* as a method for designing Digital Nudging strategies injected into User Experience. The approach uses semantic priming strategies by linking features targeted by particular nudges in an Extended Feature Model diagram. Hence, the stimulus of persuasion is not the price, but rather characteristics that comprise features. We adopted the taxonomy of ten nudging methods (simply called nudges) introduced in [3] and envisioned an agile modeling method. It features extended formal semantics by grouping several nudging methods targeting a specific feature into a Digital Nudge construct. This is associated visually and at machine-level with workflow elements of User Experience in UI navigation scenarios.

The paper reports on a *Design Science* project in Human Computer Interfaces (HCI) introducing persuasion methods from psychology linked to usage scenarios. It bridges a gap between UX/UI design of applications, design of Digital Nudging strategies and a portfolio of

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objectives targeted by them. The portfolio takes the form of feature decomposition graphs, which can later represent stakeholders goals by analogy. To treat this, our research proposes as artifact a modeling method expanding from pre-existing modeling languages. Firstly, we add modeling of Digital Nudging associated to UX flow modeling we developed in previous work; secondly we link this to an Extended Feature Model. They are interlinked by hyper-references in a demonstrator that is a modeling tool built inside the ADOxx [4] ecosystem. As a running example we model an existing online booking service.

A controversial nudge for UX is friction, which is temporarily delaying acting upon a decision. This barrier adds steps in-between user actions giving more time to reconsider their choice. Proposed modeling language abstracts the *friction* nudge dichotomously in respect to the definition given in [3]: as either adding or removing friction to the User Experience. We also consider the negative impact of added friction on User Experience. This is useful for analyzing the situations in which the goal and thus feature selection in the mind of a user does not align with what the company tries to persuade. *Annoying Level* and *Avoiding Effort Level* attributes on friction nudges enable embedding user feedback from future interviews. Hence, Semantic Digital Nudging models can be continuously redesigned to adjust for better nudging while accounting for user feedback in terms of UX. This is because the effect of some friction implementations may not be the "increase in ease and convenience" as per [5], quite the contrary. The demonstrative scenario shows how friction can delay users from achieving their goals – to book fastest with most basic service choice (and thus minimal cost indicated by dynamical notation).

The remainder of the article is organized as follows: **Section 2** presents an overview of the research methodology. **Section 3** discusses related research. **Section 4** formulates the problem tackled and puts it into context. **Section 5** presents the objectives of the problem treatment and specific requirements. **Section 6** exposes design and development decisions for the treatment and **Section 7** shows demonstration scenarios. Conclusions end the paper.

2. Methodology

For carrying out present research we have aligned our process to the Design Science Research methodology [6]. Previous DSR iterations focused on designing a UI process automation solution for mundane tasks. An RPA/UX modeling method resulted for representing UX processes connected to contextual enterprise resources and UI transitions [7]. The DSR iteration at the core of this paper customizes it for the domain specificities of modeling Semantic Digital Nudging. Peffers DSR Process model in [8] has been used as a reference workflow and current section summarizes its implementation.

Problem identification and motivation commenced this iteration and is reported in **Section 4**. A literature review condensed in **Section 3** aided in problem and objective definition. We tackle lack of a centralized method for UX designers to represent in a linked fashion diagrammatic designs of UX workflow, Digital Nudging strategies and Feature portfolios. A modeling method-based treatment enables semantically linking of HCI steps to specific descriptions of digital nudges that reference particular features/objectives. Choice architecture is the design of how options are presented. Proposed treatment can also raise awareness of healthier alternatives since online choice architecture can be cumbersome.

Next, *Objectives of a solution* were formulated and synthesized in **Section 5**. UX designers with managers will put the vision into knowledge form: to strategically design User Experiences that realize Digital Nudging policies. Simulations based on quantitative queries should be enabled – i.e., totalize extra time the user takes based on friction nudges and UX design.

Design and development were concerned with defining and implementing functionalities of the modeling method. These are discussed in large in **Section 6**. We embedded inside this DSR step the Agile Modeling Method Engineering (AMME) methodology [9] further divided in 5 cyclic steps: *create, design, formalize, develop, deploy/validate*. It was applied up to now in 2 iterations, first for the Digital Nudging UX extension, then for implementing Extended Feature Model type. Due to the cyclic nature of AMME, we juggled steps back and forth between them.

During *Demonstration* phase we used the modeling tool deployed using ADOxx to model an online flight booking service. A walk through exemplary models and how they reflect *Semantic Digital Nudging* is showcased in **Section 7**. At each stage of the iterative DSR process we came back to the method and adjusted design and implementation of the method and models.

As the current DSR iteration is not finalized, a thorough *Evaluation* has not yet been made. Instead, the focus was on demonstrating implementation feasibility by requirements coverage of exemplary models. The final step of *Communication* is instantiated in the present report.

3. Related work

To define any aspect of a choice architecture that changes people's cognition and behavior [10] the literature assigned the term *nudging*. The authors of [11] suggest that digital nudges respect the interest of the targeted person, do not change the economic incentives significantly or forbid any options. The work of [1] later analyzed this concept's adaption to the online medium. Digital nudging employs UI design and product selection to influence buying behavior by applying common biases in human decision making. When influencing with the goal of user satisfaction, the work in [12] reported hybrid nudges to effectively guide online users to make healthier food choices by reducing cognitive effort. Their results are in line with related research on nudging in health domain [13] where German public approval is high.

Works such as [10, 11] provide taxonomies of nudging mechanisms in Information Systems. The first refines the taxonomy of the second by studying recommender systems as applications of nudging. The classification includes 4 categories of nudging mechanisms: decision *information*, *structure*, *assistance* and *social appeal*. In [16] a process model for designing nudges additionally considers besides UI design the form and content of the information as means of nudging.

To better fit client needs, the authors of [17] designed an architecture for *smart* digital nudging-based recommender systems. Gently pushing public transportation users towards choosing greener alternatives involves collection of integrated data, processing and creation of user profiles. This would mitigate the user annoying that added friction causes by being aware to user choices and reducing recommendations when the nudging strategy fails, instead of feeding them the same UX . The idea of digital nudging for guiding a more sustainable usage of work, health and commerce apps is captured in [18]. The framework combines smart feedback and reminders with defaulting for the good of the user.

The work of [19] deploys a digital nudge enforcing tool that monitors code debt in Credit Suisse software. It provides visual cues to address debt responsibility at its roots – in the decisions of each developer. A method for digital nudging of recommendations in e-commerce by the authors of [20] uses a Knowledge Graph to feed the engine business knowledge besides traditional customer related data. This is close to the present work, by using AMME to setup a diagrammatic tool for a business-centric view of prioritization rules. Models are exported in RDF form to power knowledge-intensive nudging in a recommender engine.

The authors of [3] reviewed literature on application of nudges classified by domain, including *E-Commerce*. In [21] efficacy is evaluated by assessing user's attitude towards nudging in cookie disclaimers biasing text and prompt design. An efficacy increase of friction nudge (through pop-up confirmation) over default nudge (using opt-in UI element) is showcased in [22]'s experiment. The authors of [23] experiment on the impact of overt (through semantic priming) and covert (by defaulting) hybrid digital nudging in an Online Customization System for travel packages. In [2]'s E-Commerce experiments the *reinforcement* digital nudge is achieved through semantic priming.

We decompose features targeted by nudges in Feature Diagrams – first introduced in 1990 by the Feature-Oriented Domain Analysis (FODA) method [24]. The semantics of Feature Models have been analyzed and formalized by the authors of [25] following implementation variations in software product lines. We also based our metamodel on their analysis of the Extended Feature

Model in [26]. Its increased flexibility stems from using UML-like cardinalities over the base FODA model and moving optionality from feature instance to the decomposition relation.

4. Problem identification and motivation

The field of HCI is dominated by behavior-oriented empirical studies, lacking in design theories, methods and artifacts (except for some non-scientific practitioner recipes). We felt that reviewed literature was too strict, with works either reviewing nudging patterns and scenarios, others focused on behavior changing. Few tackled real data-enhanced methods of smart nudging and enterprises could benefit from an encompassing method of strategic HCI design. A cause of this gap is heterogenous management and representation of UX, product features and nudging knowledge. We fill this gap by introducing a method for UX designers and marketing planners to represent in a linked way knowledge that is typically represented disparately. In this proposal, feature portfolios and digital nudges that strategically target the items should be attached to each step in the UX workflow. We are repurposing workflow patterns to understand the phenomenon of digital nudging, to systematize its design patterns, and ultimately to offer a domain-specific modeling method for incorporating such patterns into UX workflows and for assessing/simulating their impact on UX.

Design Science Research addresses artifacts in context [6]. The social context influenced by our treatment comprises company *stakeholders that want to implement semantic nudging mechanisms in the customer-facing applications.* The business relevance of it is motivated by facilitating companies to design and represent UXs and associated know-how for influencing buying behavior. Because this is an integrated modelling method it should be advantageous from a cost-profit perspective as the need for integrating disparate resources and tools is diminished. UX designers shape the choice architecture around the user experience in alignment with the nudging policies. They have to be informed about product features, stakeholder objectives and collaborate with managers who do not master technical jargon. Thus, a visual model offers a communication method comprehensible by many. The proposed method enables executives to design diagrammatic Feature Models intuitively which can be referred by the UX designer from within UX Workflow/Digital Nudging models.

We formulate the problem statement in the tradition of the DSR template [27]:

> *Improve* ***nudging knowledge management*** *(problem context)*
>
> *...by treating it with* ***an integrative agile modeling method for Semantic Digital Nudging*** *(artifact)*
>
> *...to satisfy a need for* ***aligning UX workflows with nudging mechanisms and product-service features*** *(requirements)*
>
> *...in order to* ***facilitate the reuse, analytics and management of nudges aligning better to organizational strategies and user satisfaction*** *(goals)*

5. Objective

The main objective is to support visual design of methods to persuade users towards specific options as they are guided through the UX. Secondly, the resulting conceptual models should enable analytics of Digital Nudging policies efficiency while considering impact on UX. This requires embedding values from post-deployment interviews with users assessing their effort of avoiding certain nudges. Thirdly, for competency-based evaluation and finer capturing of model semantics, a sufficient amount of unpacking has to be iteratively made for concepts and relations in the metamodels. Lastly, the resulting modeling method should be agile in response to requirements that might arise and support an iterative process. This is covered by adhering to the AMME methodology.

From the exemplary scenario of flight booking described during problem identification the solution addresses the following requirements:

- To model with added semantics the UX workflow – i.e., highlighting economic paths for user and actions caused by nudges *(UX designer)*
- To model in the same diagram Semantic Digital Nudges linked to specific steps in UX *(Business owner decides where to put these nudges)*
- To model using feature-based decomposition an Extended Feature Diagram aligned to the ontology established by [26] *(Managers)*
- To set hyperlinks between nudge implementation instances in UX/Digital Nudging diagram and targeted features in Extended Feature Diagram *(UX designer)*
- Clear visual notation for enhancing understanding of diagrams by people with various technical skill levels
- To enable analytics of UX impact and nudging efficiency through concept instance attributes – i.e., containing user feedback encoded as integers
- To allow queries at a sufficient level of detail for Knowledge Management that facilitate better (re)design of models and propel Digital Transformation

The requirement of assessing friction nudges impact on UX partly answers concerns of [14]'s literature review on nudging in recommenders. The authors reported that no paper investigated if the participants felt manipulated or coerced by proposed nudges. In respect to the original definition of this practice, they suggest choice architects to check for user feedback in order to avoid any unwanted manipulation. We felt this is important and transformed it into an objective motivated by some examples of nudges we perceived as over the board in our demonstrative booking scenario. Unnecessary services were recurrently advertised obsessively in spite of the user keeping their status quo option. This added some delay with processing the nudge and friction caused by scrolling and click actions to "parry" it. Authors of [10] stated that: "To count as a mere nudge, the intervention must be easy and cheap to avoid". We rather perceived the overall nudging towards buying the more profit-leading services as *nagging* (defined in [3,28]).

6. Design and development

To integrate specificities of Digital Nudging, UX and Feature Models we conceived as artifact a domain-specific conceptual modeling method. At this stage of the DSR cycle we covered eponymous steps from the lifecycle of the methodology Agile Modeling Method Engineering (AMME). AMME hybrid modeling framework enables developing the modeling language, procedure and algorithms [9] that optimally abstract and represent real world concepts and permit changes in requirements [29]. Our method was developed in 2 main iterations for the 2 model types with inter and intra iteration switches.

First iteration starts with the *create* step by acquiring knowledge and eliciting requirements for modeling Digital Nudging. Preliminary requirements and conceptual knowledge were drawn in a discussion. We agreed to start by extending a modeling method that we have previously tailored for representing RPA/UX. We filtered out concepts pertaining to automation and preserved the *hardNext* relation that denotes succession between two process steps. We created a preliminary model draft on the UX of booking a flight from a low-cost company. It included notes as concept placeholders, arrows and legends which progressively responded to the solution requirements. It served as an agile-proof pre-metamodel through the lifecycle.

Additional requirements arose and we returned to the *create* step. We extended the modelling method with a *Digital Nudge* concept and the *implements* relation that links a UX Action to a Digital Nudge. We conceptualized the ten digital nudges from the taxonomy of [3]. Furthermore, a digital nudge is split into a couple of abstract concepts: overt and covert. Overt digital nudges utilize information to explicitly indicate expectations regarding user choice. Covert nudges target the presentation format of option information, rather than its contents. The work of [23] solely exemplifies priming (which is a part of the reinforcement digital nudge) as overt and default nudge as covert. Deception was later denominated as covert by [3] and we extrapolated the binary classification of [23] to the ten nudging mechanisms in [3].

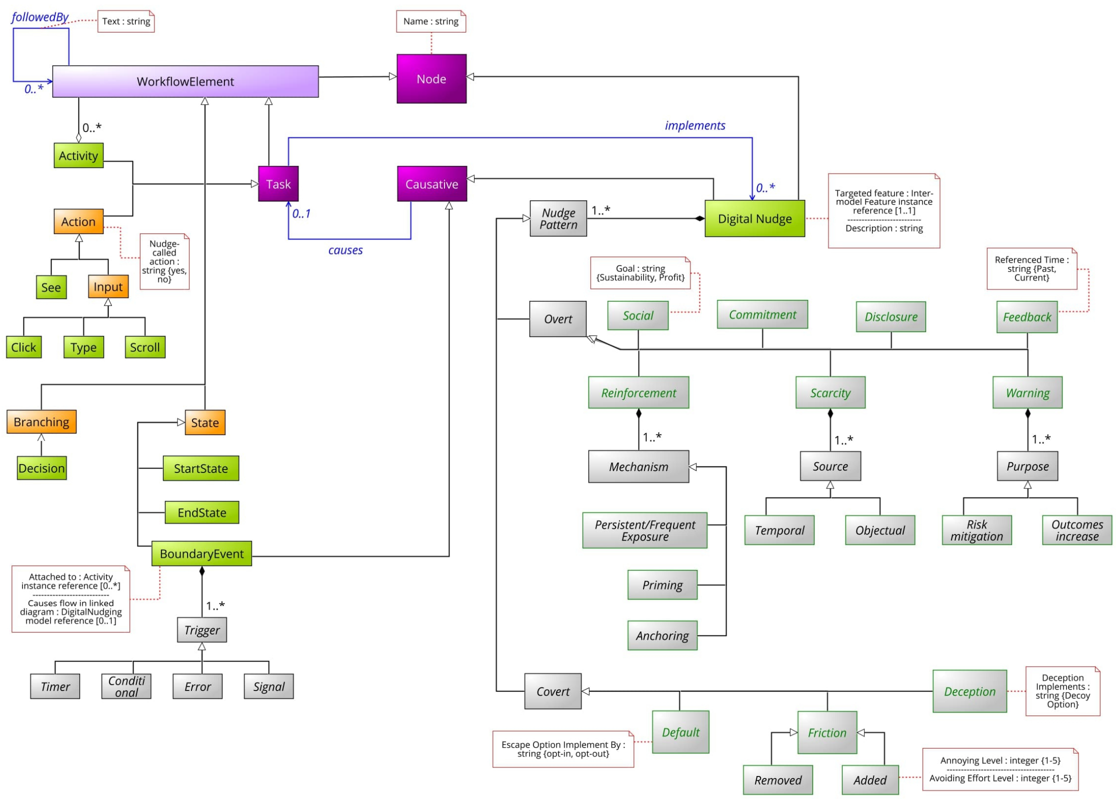

Figure 1: Metamodel of UX/Digital Nudging conceptual models

In the *design* step we created a metamodel for Digital Nudging in the context of UX. It is depicted in **Figure 1**. Concepts under the *WorkflowElement* category existed in the RPA/UX metamodel of the previous project. These can follow one another (through *followedBy* relation) and are either containers (*Activity*) or atomic steps such as *Action*, *Decision* or *Start* and *End States* which replicate BPMN [30] events. An Action is either *See* which is the user identifying a particular UI element (substitutable by Computer Vision) or an *Input*. In this DSR cycle we have integrated the *BoundaryEvent* concept from the BPMN standard making it a kind of State that can be attached on the border of *Activity* instances or stand alone and reference a couple of them. We added a machine-readable property to mark a "*Nudge-called action*" introduced by friction nudge and semantically differentiate these in queries from regular UX Actions. We have added a new *Action* subtype, *Scroll*, which is called upon the user by the usage of nudging.

We have added the Digital Nudge sub-hierarchy in the right part of the figure. A *Digital Nudge* can employ several patterns from the ten in [3]'s taxonomy, and each pattern (further termed simply nudge) can reference multiple mechanisms that enforce it. These nudges are:

- *Social* uses choice popularity, making the user feel like belonging to a community
- *Commitment* aims to keep the user consistent with previous choices
- *Disclosure* offers clear information about an upcoming choice
- *Feedback* provides information about a past or current behavior of the user
- *Reinforcement* increases salience of behaviors and choices in the mind of the user

- *Scarcity* assumes that an option which may become unavailable in the future is valuable
- *Warning* overtly points the user towards risks or consequences
- *Default* subtly keeps the option targeted by the choice architect unless the user intervenes
- *Friction* introduces "change effort" to persuade user's choice reconsideration
- *Deception* usually introduces a decoy option to modify the user's perception of variants

In the *develop* phase we implemented a tool for creating UX/Digital Nudging models. We used the ADOxx environment based on the envisioned metamodel and specifications. The notation (visual depiction) changes dynamically with labels to the right of *Digital Nudge* concept denoting employed patterns, and two visual icons denoting (c)overt. Addition or subtraction of UI elements is marked on the *implements* relation depiction. Iteration finished with the *deploy/validate* step by remaking the preliminary flight booking model using the newest version of the tool. Model evaluation raised the requirement of linking the Digital Nudge concept to a hinted feature.

We started the second and last AMME iteration by extracting knowledge regarding feature models. We based a metamodel depicted in **Figure 2** on that of the Extended Feature Diagram (EFD) [26] and deployed a modeling tool. To *validate* it we modeled decomposition of features in graph form for the flight booking scenario. We then returned to propagate these changes in the Digital Nudging model type. Ultimately, we linked features to Digital Nudge instances by means of an INTERREF attribute which accepts an instance of type Feature from an EFD. Updates were *deploy*ed to the exemplary models demonstrated in the upcoming section.

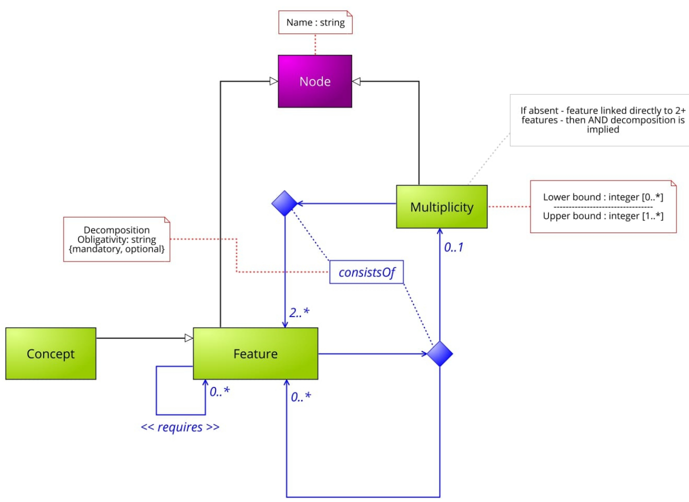

Figure 2: Metamodel of Extended Feature Diagram conceptual models

Implementation-wise, we carefully weigh on which concept to apply unpacking and repacking. We implied that when modeling friction nudges there is a delay for the user processing it, and *Delay* will not propagate into a separate Action type. This is a case of repacking to declutter the diagram. We unpacked the inherited Action by adding the "Nudge-caused action" attribute and Scroll subtype to the pragmatic Input actions. A See Action that *implements* Nudge or its outgoing *causes* relation Action target imply a nudge-induced Delay.

7. Demonstration

A snapshot of the flight ticket booking process for a low-cost company is depicted in **Figure 3**. Our goal was to book a single passenger ticket fast with minimum cost (paying just for basic features). The options picked in previous screens were consistent with this usage strategy. Embedded UI logic presents in response three advertisements where they try to persuade the user in upgrading to costlier services. *Semantic priming* presents as stimulus the feature of coverage for "*travel uncertainties*" in the top grid for the eye to catch it first. This is *reinforcing* the company's premium package. Extended features listed might be evaluated by the user's cognitive system as superior to their status-quo option, which is the cheapest bundle. An interaction which couldn't be captured in rendered mockup is dynamic addition or subtraction to/from the interface. Appearance of the *Privilege Pass* grid right after completing *Passenger information* lures towards exploring the option by *disclosing* discounts to the overall ticket price.

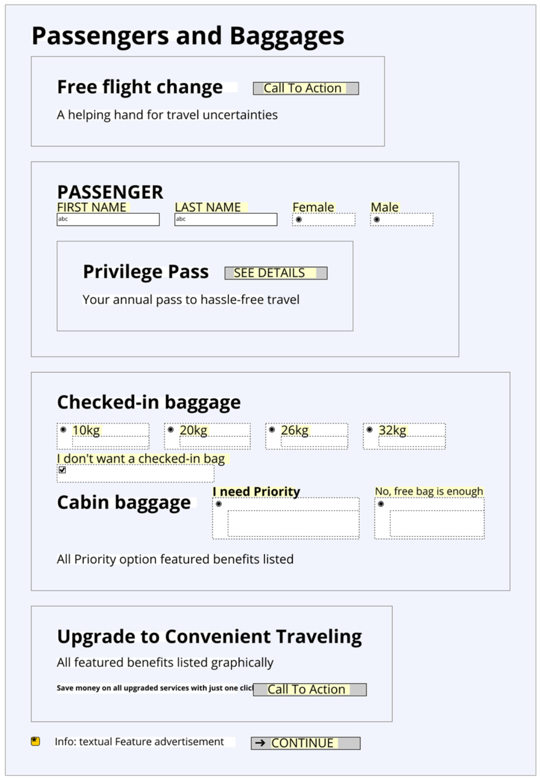

Figure 3: Flight Booking Service UI Mockup (Passengers screen)

We translated the UX workflow in the Passengers screen using the Semantic Digital Nudging modeling method. It is depicted in **Figure 4**. We will demonstrate the Digital Nudges implemented by Actions in the "*Complete PASSENGERS Screen*" Activity. This directed relation is visually denoted by the *implements* text. It denotes intention of the choice architect to hint the user into opting for a feature in the organization's catalogue. The two costlier bundle alternatives, *Free flight change* and *Convenient Traveling,* are nudged at extreme positions in the UX process. The flight change option is the first alternative with which the user is overtly persuaded after being dismissed in favor of the Light traveling bundle on a prior screen. The nudge pattern is *Reinforcement* with the mechanism of persistent/frequent exposure. Both icons that correspond to a hybrid overt-covert pattern are dynamically loaded at the top-left of the concept.

In the case of nudging towards the *Privilege Pass*, Added *Friction* delays the user by having to see and process the nudge's visual presentation. Although this classifies as a nudge-called action we agree not to depict nudge-called *See Actions* as seeing the nudge is implied. Digital Nudges can *cause* the user to make an input, i.e., scrolling over the grid advertisement to avoid *Convenient Traveling* nudge. If they close and/or open novel UI elements, then Digital Nudges *morph* the *UI* and symbols decorate the connector accordingly.

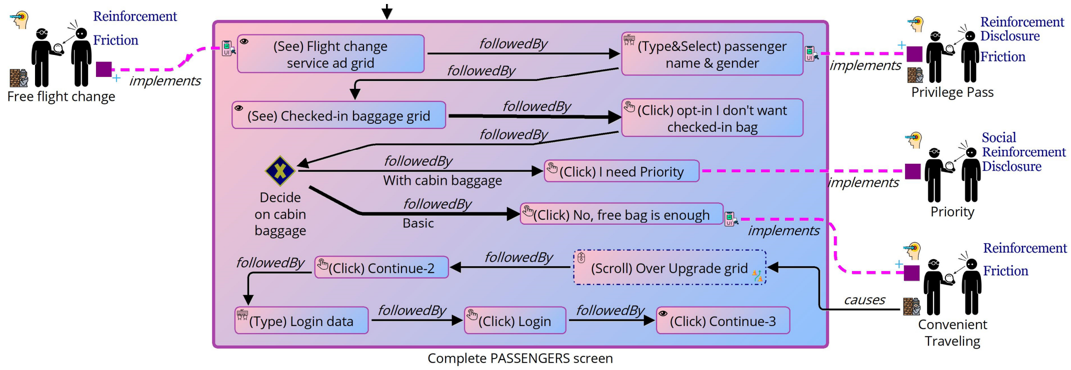

Figure 4: Excerpt from Digital Nudging model

Fractionally depicted in **Figure 5** is a decomposition hierarchy of features. They are partly targeted by the Digital Nudge instances in associated model. *Flight ticket* is the root *Feature* that gets decomposed either mandatory or optionally into sub-features. For that, it is called a *Concept*. In FODA, the *Concept* was restricted to a single node and it was the root of the feature tree. To fit the graph structure of model diagrams, we permitted multiple nodes of type *Concept* as either root or they can exist outside of composition. *Credit wallet* Concept is an example of stand-alone feature that is the target of a Nudge. It is not part of the flight ticket, though, having a lifetime/scope of its own. Similarly, *Privilege Pass* subscription is a stand-alone entity, but this time it can become a part of Flight ticket options.

The *Multiplicity* node specifies the minimum and maximum number of required options from a group of sub-features. Its omission equivalates to AND decomposition with the cardinality being the total number of children. For instance, *Light Traveling* feature mandatorily consists of *Carry bag* and *Prior day check-in*. A *Bundle* must consist of one of the three options and at most one, and this is an example of XOR decomposition.

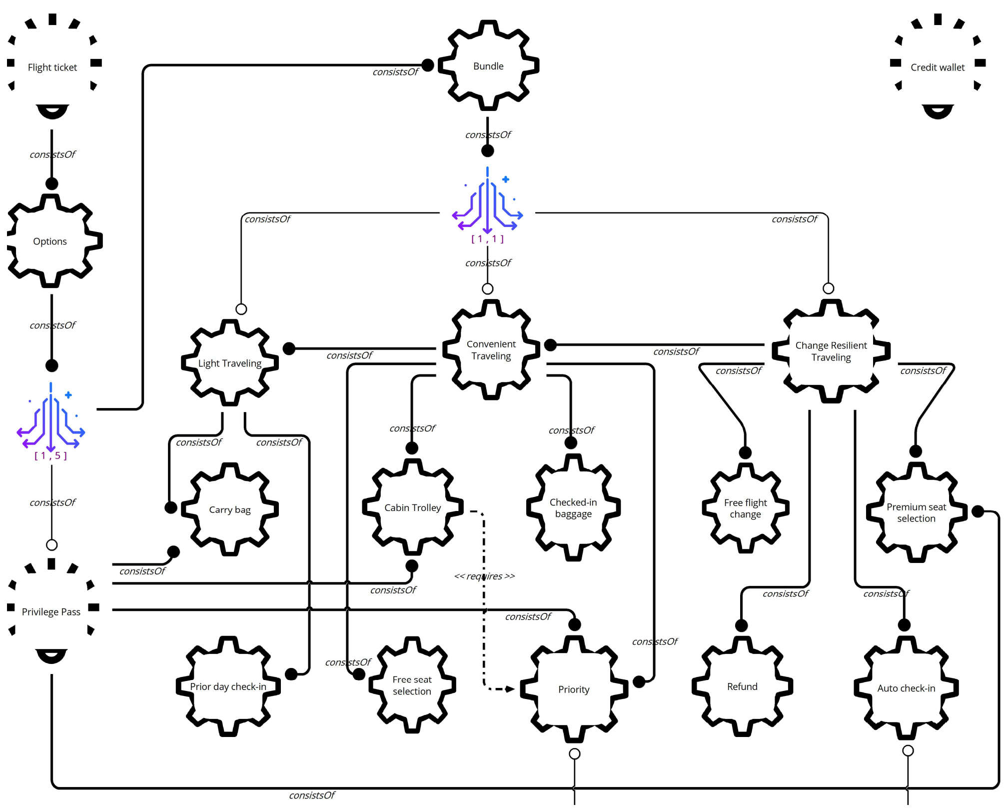

Figure 5: Excerpt from Extended Feature Diagram

UX Activities can have *Boundary Events* attached to them as seen in the left part of **Figure 6**. They are exceptional events borrowed from the BPMN standard that happen conditionally or after certain time passes. Here the designer uses one on the last screen of payment to hurry the user up if a time threshold is reached without them advancing through the booking. Since prices might fluctuate, this induces the idea of price and ticket *scarcity* based on the hypthosesis formulated by the authors of [31]. It states that products with time-related *purchase pressure cues* will be chosen more often.

Exemplified *Scarcity* nudge can be edited to link the *targeted feature* from an EFD, or by adding a policy explanation in the machine-readable *description* property. Editing screen appears on the right side of **Figure 6**. Because this nudge requires the user to click a button it adds *Friction* to the UX, which can be quantitatively assessed from end-users. The collected values can be retrieved later by queries that assess an estimated delay in seconds added by the Digital Nudge.

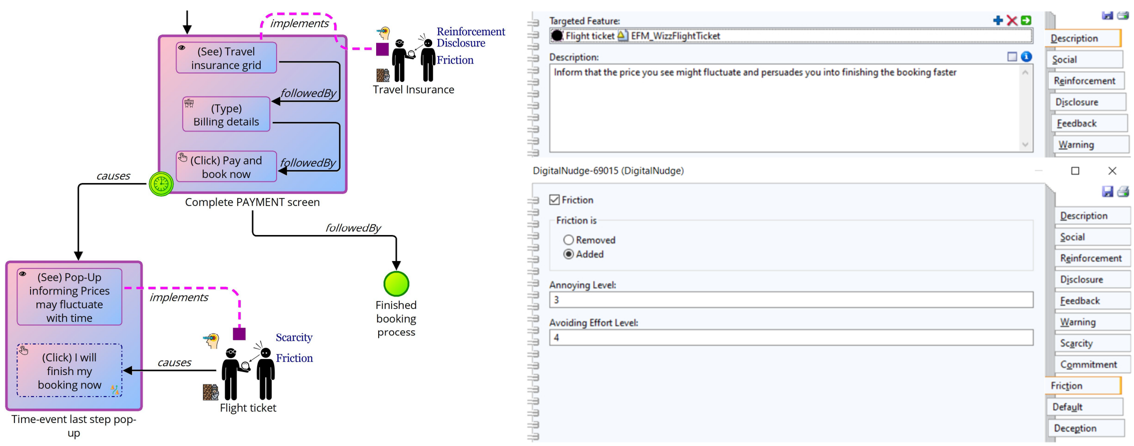

Figure 6: Time-based triggered Activity (left) and Nudge model-time properties (right)

8. Conclusion

The paper reports on a Design Science project where an artifact in the form of an agile modeling method was engineered. It enables Semantic Digital Nudging as a strategy for integrated design of Digital Nudges at the level of User Experience and with semantic enrichment from Extended Feature Diagrams. The goal of the artifact is to support the process of creating smarter nudges that better integrate with product feature strategy and are enhanced by the UI/UX design. This is achieved by better aligning UX requirements to nudging policies, product feature portfolio and user satisfaction since the two model types are understandable at a high level by less-technical people. The inclusion of machine-readable attributes that asses level of friction to UX helps digital choice architects achieve their organizational goals by understanding UX and actual nudging effects on users. As per [32] designers must be aware of the ethical implications of nudges, but this is a topic beyond the scope of this paper (see [33] for a discussion on nudging ethics). Therefore, we align our goals to those of [1] contributing to the state of the art with an artifact in the form of a modeling method-based deployed tool for semantically designing and assessing Digital Nudging.

We intend to end the iteration with a competency-question based evaluation upon collected requirements. Questions will cover post deployment analysis on UX by using attributes on modeled instances that trace friction nudges. Cross-model Knowledge extraction will be assessed. In future DSR iterations there remains to investigate additional nudging patterns in literature. Mainly the set of Digital Dark Nudges in the work of [34] and the taxonomical differences of the 23 nudges classified by the authors of [15].

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