UNT Petri Nets Theory Applied to Rich-media Recordings of Apple Mobile Devices

Abstract: The "Everyone Can Code" worldwide program of Apple Inc. that was implemented also by VSB-Technical University of Ostrava is primarily focused on teaching programming technologies in the new Swift programming language with the support of the Swift Playgrounds development environment. It is the revolutionary graphical application implemented for the Apple iPad tablets which makes learning of the Swift programming language interactive and very fun. The main problem that had to be solved when deploying the Swift programming language learning process with the support of the Swift Playgrounds running on Apple iPad tablets was the need to record presentations with using of the rich-media technologies and publish them on-line and on-demand. Successful design and implementation of the parallel software environment that meets the requirements of comprehensive multimedia visualization of the educational process that is available on-line or on-demand required the use of the UNT (*Unique-Number Token*) Petri nets formal theory.

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Introduction

The "Everyone Can Code" (ECC, 2020) worldwide program that was created and launched by Apple Inc. in 2017 is primarily focused on teaching the new Swift programming language with the support of the Swift Playgrounds (SWP, 2020) and Apple Xcode development environments. Swift Playgrounds is the new revolutionary graphical application implemented specifically for the Apple iPad tablets which makes learning of the Swift programming language interactive and very fun (see Figure 1). The Faculty of Economics has operated an authorized training center within the framework of Apple's worldwide Apple Authorised Training Centres for Education (AATCe) program since 2013.

The main problem that had to be solved when deploying the learning process based on the Swift Playgrounds development environment was the need to record all the teacher and students presentations running made on the iPad tablets environment with using of the rich-media technologies and to publish them on-line and on-demand. It was then necessary to design and implement a single-purpose programming support based on Apple and Mediasite Recorder technologies determined for the generally distributed computing environment. The main purpose of this support is to ensure a high-quality learning process with using of mobile technologies and the ability to realize its audiovisual recording based on the rich-media technologies and available on-line or on-demand. Formal mathematical theory of Petri nets was chosen (Diaz, 2009) to design and implement a solution to this problem. The class of high-level UNT (*Unique-Number Token*) Petri nets based on the author's definition of the class of the SNT (*Single-Number Token*) Petri nets (Martiník, 2015) (Martiník, 2018) was introduced for these requirements.

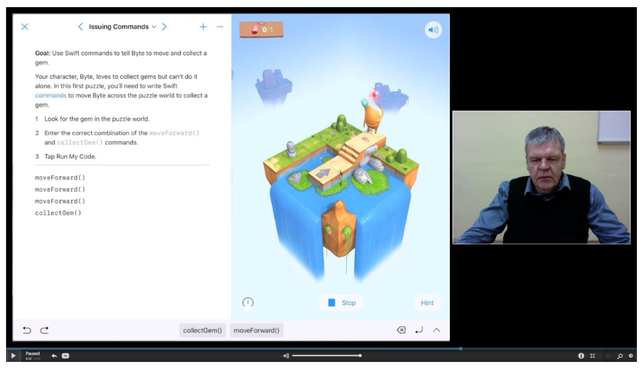

Figure 1: Rich-media recording of Swift Playgrounds application

Materials and methods

UNT Petri nets

The system modeled by UNT Petri net is described with the bipartite graph containing finite non-empty set P of the **places** represented by the circles and used for expressing of the conditions of the modeled system; finite set T of the **transitions** represented by the rectangles and describing changes in the system; finite set A of the oriented **arcs** that connect the given place with the transition or the given transition with the place and that are drawn as lines with the arrows; the **arc function** AF assigning each arc with the integer number expressing the kind of removed or added token from or to the place associated with that arc when firing a particular transition, such that the values of the arc function AF associated with each output arc of the given transition $t \in T$ must be different from each other and for the given value of the arc function AF of each output arc of the selected transition $t \in T$ there must be an associated input arc of that transition t with the same value of the arc function AF; the **priority function** TP associates with each transition its priority (such priority has the default value of 1, if not explicitly indicated in the net diagram); the **initial marking** M_0 then expresses the initial status of the modeled system and it assigns each place with the (possible empty) subset of mutually different natural numbers called **tokens**.

Apple technologies installed in AATCe training center

AATCe training center is equipped with the **iMac** computers, **iPad** and **iPhone** mobile devices, large format multi-touch display **65" NEC MultiSync V651 TM**, **Apple TV** and **AirPort Express** devices. AirPlay Mirroring technology is then intensively used during the teaching process to wirelessly mirror screen content of desktops or mobile devices of students and teacher on the NEC V651 HDTV with a large screen or on the teacher iMac computer and for content sharing to other students. It is also possible to make a real-time recording of the teacher iMac screen content by the rich-media technology recorder software **Mediasite Recorder** and to publish it on-line or on-demand.

Results

The resulting UNT Petri net modelling functionalities of AATCe classroom

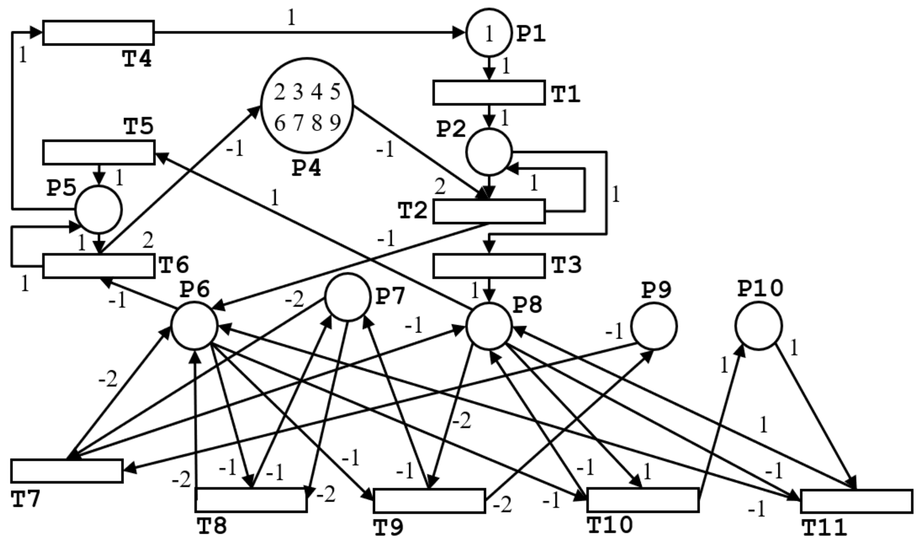

Figure 1: AATCe classroom functionalities modeling with using of UNT Petri net

Other results achieved

- over 90 presentations and their recordings were realized with the support of AATCe training center equipment and the comprehensive collections of several following subjects are available;
- three courses of the Swift programming language for the students of the fourth year of the Maticni Grammar School in Ostrava have been successfully completed as the part of the implementation of the "Everyone Can Code" program; each of these courses was attended by 20 students;
- a total of 21 students with special needs are registered at the faculty in this academic year, who can use "barrier-free" access to informations through the recorded presentations; the next pilot activity prepared with using of the AATCe classroom equipment supporting these students mainly involve automated adaptation to their needs, e.g., transcription of spoken text of the lecture recorded by the recording and assistance service into the written text and their availability on-demand;
- various forms of asynchronous communication between the teachers and the students were initiated and started to be used in the so-called pre-learning process, where students have available records of selected topics of the subject before the lesson and they can study them in advance and they are already equipped with the information about the given topic;
- asynchronous communication is used when students are actively involved in the realization of recording of their individual presentations, especially when defending their processed projects.

Conclusion

In general, the implementation of the rich-media technologies and the "Everyone Can Code" worldwide program at the Faculty of Economics contributes significantly to the mobilization of students in the learning process. Coding is an essential skill for the students of our university and learning to code teaches them how to solve general problems with using of the algorithmic techniques and the formal procedures. Through realized records of lessons the students can repeat and better understand the topic, which of course has a positive impact on their overall level of knowledge and improvement in their learning outcomes. Therefore, asynchronous communication becomes an excellent tool for promoting inclusive education by providing access to the learning process from multiple points, different times and any number of repetitions. With regard to the level of equipment of the school and students using mobile tools (tablets, notebooks), nothing prevents immediate frontal implementation.

References

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