Process Petri Nets Theory Applied to Management of Full-Time/Distance Form of Teaching

Abstract: The beginning of the second wave of the COVID-19 pandemic in the Czech Republic brought very specific requirements for the organization of the teaching process at the Faculty of Economics VSB-Technical University of Ostrava. The teaching process took place simultaneously in full-time and distance form and it was necessary to implement its comprehensive recording available on-line or on-demand. It was not possible to gradually equip selected classrooms with cameras and other systems due to the current situation, but it was necessary to effectively use their existing equipment that could be supplemented with available mobile components to meet the requirements of the teachers for this type of teaching. The design and implementation of the distributed software support that meets the requirements of multimedia recording of the educational process and that was implemented also with the application of the theory of process Petri nets is the subject of this article.

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Introduction

The beginning of the second wave of the pandemic COVID-19 in the Czech Republic brought very specific requirements in the field of information support for the organization of the teaching process at the Faculty of Economics VSB-Technical University of Ostrava that took place in full-time and distance form all at once. A typical example of this type of teaching process was the implementation of lectures and exercises for the Czech and foreign students at the same time. Full-time teaching took place for the Czech students in the relevant classroom. Foreign students (typically the students from the Slovakia or China) usually could not cross our state borders due to a pandemic and they participated in the teaching process in real time by the distance form of learning. The pedagogical staff formulated the following requirements for the provision of information support for the students participating in this specific form of full-time/distance teaching:

- the need to ensure voice and video communication of the teacher with full-time and distance students in real time and its recording;
- the need to capture and record the movement of the teacher in the classroom and his voice communication with the students present in this location;
- the need to capture and record the teacher's presentation including the content of his record on a classic blackboard located in the classroom;
- the need to display and record the content of workstation screens of selected students present in person within the implementation of exercises in computer classrooms.

It was not possible to gradually equip selected classrooms with cameras and other systems due to the current situation, but it was necessary to effectively use their existing equipment that could be supplemented with available mobile components to meet the above requirements. We will demonstrate the solution used on the example of the classroom of an authorized training center within the worldwide program of Apple Authorized Training Centers for Education (AATCe, 2021) that has been operated at the faculty since 2013 in this article. It was necessary to design and implement the single-purpose programming support based on Apple technologies determined for the generally distributed computing environment with the stated properties. Mathematical theory of Petri nets was chosen (Diaz, 2009) for that reason. The class of low-level process Petri nets (Huang et al., 2012) was used for these requirements and it has been significantly applied at the design, verification and implementation phases of the necessary hardware and software support preparation.

Materials and methods

Process Petri nets

Process net (PN) is an ordered 7-tuple $PN := (P, T, A, AF, TP, IP, OP)$, where P is the finite non-empty set of the **places** that express the conditions of the modeled process and that are represented by the circles; T is the finite set of the **transitions** that describe the changes in the modeled process and that are drawn by rectangles, $P \cap T = \emptyset$; A is the finite set of the **arcs**, $A \subseteq (P \times T) \cup (T \times P)$; AF is the **arc function**, $AF: (P \times T) \cup (T \times P) \rightarrow \boldsymbol{N}_0$ such that $AF(x, y) \in \boldsymbol{N}$ iff $(x, y) \in A$, $AF(x, y) = 0$ iff $(x, y) \notin A$, i.e., the arc function AF assigns with each arc the natural number (with the default value of 1 if not explicitly indicated in the PN diagram) that expresses the number of removed or added tokens from or to the place associated with that arc when firing of the given transition; TP is the **transition priority** function, $TP: T \rightarrow \boldsymbol{N}$, that assigns with each transition the natural number that expresses its priority (with the default value of 1) and during the transitions enabling and firing process the rule will be followed which determines, informally said, that from the set of enabled transitions that are in conflict the one will be fired whose value of the transition priority function TP is the highest; IP is the **input place**, $IP \in (P \setminus RP)$ and it is the only one place with no input arc(s), i.e., $\bullet IP = \emptyset$; OP is the **output place**, $OP \in (P \setminus RP)$ and it is the only one place with no output arc(s), i.e., $OP\bullet = \emptyset$; PN is the **connected net**. **Process Petri net** (PPN) PPN is the ordered couple $PPN := (PN, M_e)$, where $PN := (P, T, A, AF, TP, IP, OP)$ is the PN and M_e is the entry marking of the PN PN.

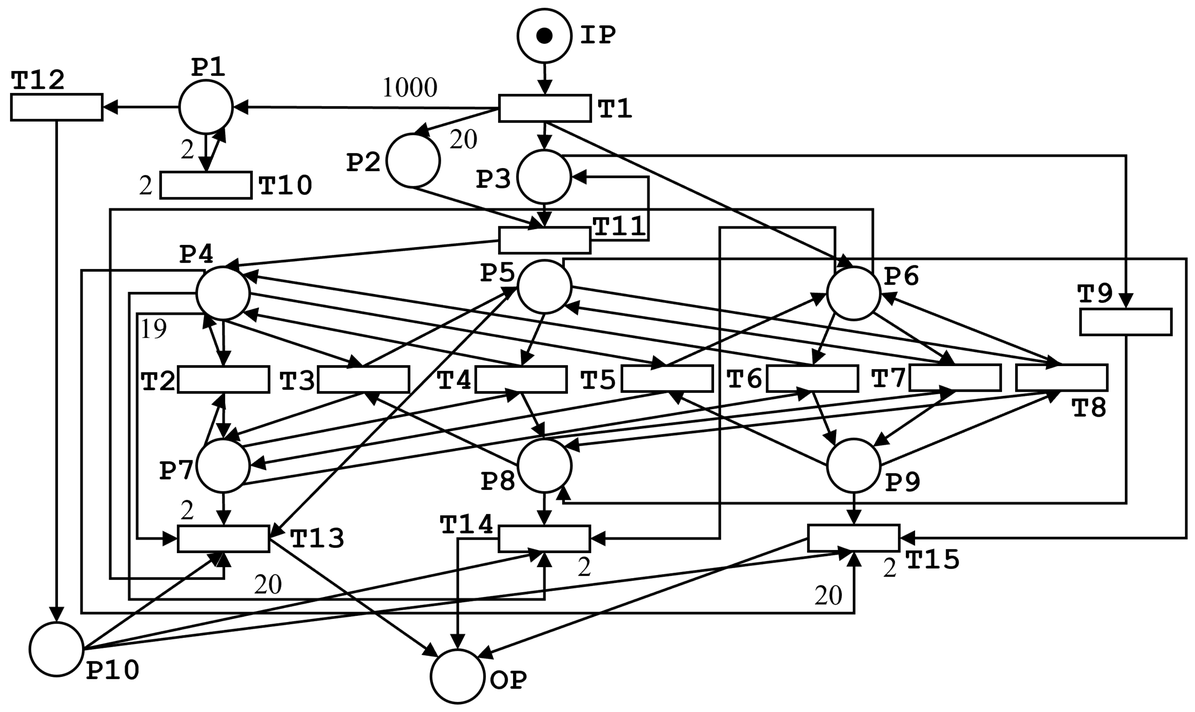
Technologies installed in AATCe training center

The AATCe training center is equipped with **iMac** computers, **iPad** mobile devices, a large format **65 "NEC MultiSync V651 TM** multi-touch display, **Apple TV** and **AirPort Express** devices, a visualizer **ELMO L-12iD** and a **Kandao Meeting** (Kandao, 2021). Kandao Meeting is mobile 360-degree smart camera equipped with eight omnidirectional microphones and two FullHD lenses that work based on artificial intelligence and it enables a full-fledged recording of lectures and exercises of individual subjects with the use of intelligent monitoring of the teacher and automatic focusing that automatically focuses on active participants in the teaching process. It is also possible to record the contents of the teacher iMac screen in real time using the **MS Teams** and **BigBlueButton** video conferencing systems and publish it on-line or on-demand.

Results

The resulting process Petri net modelling functionalities of AATCe classroom

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



Other achieved results

- over 110 presentations and their recordings were realized with the support of AATCe training center equipment; the rich-media recordings were published in the on-demand mode through the LMS system Moodle; statistical data on monitoring students' access to the recordings of presentations show that each student for whom a given record of the presentation was intended within the given taught subject viewed this presentation at least once (on-line or on-demand) and 63% of these students watched the given presentation more than once,
- various forms of synchronous and asynchronous remote communication between teachers and students were started, which began to be used in the so-called pre-learning process, where students have records of selected topics of the subject before the lesson and they can study them in advance (or communicate with the teacher) and they are already equipped with information on the topic;
- synchronous and asynchronous communication is also actively used in cases where students actively participate in the implementation of the recording of their individual presentations, especially in the defense of their projects.

Conclusion

An extensive survey of students and teachers was conducted at VSB-Technical University of Ostrava concerning selected aspects of the implementation of distance learning in November and December 2020. The survey was attended by 576 students and 81 teachers of the Faculty of Economics. It showed that at this faculty, among other things:

- 47.4% of the students prefer watching of the lectures and exercises remotely in the real time and 52.6% of the students prefer watching of the recordings of presentations;
- 13% of the teachers provide recordings of their presentations before the teaching process, 39% of the teachers provide recordings of their presentations after the teaching process and 48% of the teachers do not make any recordings of their presentations;
- 68.3% of the students were satisfied with the way in which the distance form of teaching was provided.

References

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