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COMPARISON OF METHODS FOR ATTENDANCE TRACKING FOR OFFLINE AND ONLINE EVENTS IN EDUCATIONAL ORGANIZATIONS

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Abstract: *The paper compares the common approaches to track and store information on attendance for different type of events (online, offline, mixed). The parameters used in the comparison include relative complexity, cost, usage of the system for online and offline events. The parameters are chosen by the author, but they take into account other parameters on assessing similar systems by other authors. Educational organizations may need to cover different types of events (i.e. for online lessons, in-room lessons, councils, organizational events etc.). Each type of event requires different set of features, included in the tracking system. Keeping one feature often provoke inability to provide other features (i.e. providing both authorized and anonymous entries, both online and offline modes, both registered and unplanned visitors). In order to cover different case one organization may apply several attendance tracking systems. This paper treats such practice neither good or bad, but provides a scale system to choose the efficient approaches for attendance tracking based on the requirements of each event type.*

Keywords: *Attendance tracking system, Educational organizations, e-learning*
JEL Codes: *I20, D73, M15.*

INTRODUCTION

Attendance monitoring is an important process that takes part in many functions of educational organizations: work shifts tracking, monitoring students' activity at the lessons, organizing public events, logging the participants at work meetings, and much more. There is a wide choice of alternative approaches, each performing at different accuracy levels, complexity, cost, time requirements, integration possibilities, features sets, and other factors. We see that new technologies are often used to automate this process (Nikolov, B., Ivanova G., 2011). The COVID-19 pandemic brings a new breath to the topic on a worldwide scale. Especially it concerns educational organizations due to the dynamic pandemic environment (Koshyk, C., 2020, Pakhomova et al, 2021). As the transition of the courses to the online environment could mean lower performance for some courses, the attendance tracking, providing in traditional way (i.e. roll call at the beginning of the lesson) might bring the performance even lower due to the connectivity issues, audio quality, bandwidth limitations, lack of microphones at the students' side, and so on. On the other hand, the electronic attendance monitoring system can make a statistically significant difference in the end-of-term academic success rates. For instance, the outcome of the study of Childress, C., 2018 is that students enrolled in the attendance monitored courses were 2.605 times more likely to be academically successful than students who were in the courses that did not implement the electronic attendance monitoring system.

In this article the author compares different approaches for attendance monitoring, reviewing their limitations, providing the base for the educational organizations to find their approach, or a combination of approaches to cover their needs, to fit in their resources and to be ready to overcome some of the challenges, brought by their choice.

EXPOSITION

This article presents an assessment of 11 different approaches for attendance monitoring. The list of approaches includes approaches applicable for face-to-face events, approaches applicable for online events, and approaches applicable both for online and offline events. The

assessment consists of two parts: features rating and complexity rating. The first part covers 20 common features used for attendance tracking in different scenarios and event types. The features are organized in 7 groups: limits on responses quantity, visitor's verification, time limits, search functionality and fields validation, internet dependency and connectivity, accessibility, current status monitoring. These features are optional. Their availability does not mean that they are used in a particular system. Availability of some of the features depend on the particular realization of the system in the organization. The second part of the assessment includes 9 factors that are influencing the system's complexity and cost. Table 1 presents the assessed approaches.

Table 1. The attendance tracking approaches reviewed in the articles.

Code	Approach Shortname	Approach Description
F1	Barcode & RFID	There are barcodes, RFID, NFC or any other type of physical scanners/readers inside and/or outside the rooms in the building. Each visitor has his own visitor id card, compatible with these readers.
F2	Tracked by supervisor	The role of supervisor is assigned to one of the visitors in the group. This supervisor is responsible for monitoring the attended and absent visitors
F3	Prefilled sheet	The attendance list is given to the visitors in the room (eventually prefilled date, time, event name or any other information regarding the event). The list is prefilled with names of the expected visitors as well.
F4	Blank sheet	A blank sheet is given to the visitors in the room (eventually prefilled date, time, event name or any other information regarding the event). The list of visitors is empty at the start.
F5	Using biometrics	The organization uses biometric information of the visitors (face detection, fingerprints, etc.) to monitor their attendance at the events.
F6	Copy-paste guest list	The moderator and the visitors use an online meeting platform. The moderator copies the list of guests from the meeting platform.
F7	Call for guests' names	The moderator and the visitors use an online meeting platform. The moderator asks the visitors to send their names or other identification info via public or private chat.
F8	Extension to meeting platform	The moderator and the visitors use online meeting platform, that allow integrating custom modules (i.e. Zoom, Microsoft Teams, Google Meet, etc). The moderator activates an activity monitoring module from his profile.
F9	Custom attendance application	Each visitor has a device with software connected to the attendance system. After establishing the connection with the online event, the visitor marks his attendance in the software.
F10	Using online forms	The moderator creates the form for responses in a survey administration software (i.e. Google Forms).
F11	Custom meeting platform	There is an online meeting platform administered by the company. Each visitor has his own account in this system. The platform is integrated with the attendance monitoring system.

The article provides no final marks for any attendance monitoring system. Nevertheless, it provides the base for the comparison process of the listed approaches. It is valuable for the alternatives comparison in a particular situation when the decision maker could ignore the unnecessary features and add custom weights for critical features and factors. The marks for features and complexity factors are provided by the analysis of relative scientific reports and/or by the analysis of the systems' design and/or the author's experience.

The processes of attendance monitoring for each approach listed in the article are described below in the following format:

1. Initial conditions.
2. Actions for collecting the attendance information.
3. How the moderator gets the results.

Group 1. Attendance monitoring approaches for offline events

Approach F1:

The attendance information is collected by scanning barcodes, RFID tags, etc. For instance, Rjeib et al (2018) present an architecture of such a system for student attendance tracking by using RFID tags, RFID readers, logic circuit (Arduino) and a web-based application. This type of system requires issuing personal codes for each guest or connecting the tags to the existing identities of the guest (i.e. student id or staff id). Usually the personal RFID tags or card with integrated RFID chip is issued for each visitor. This system could be integrated with the security system of the organization allowing using these codes as the door keys and access permissions. This type of systems has become accessible to more fields as a significant part of personal digital devices (smartphones, smartwatches, tablets, etc.) already have integrated necessary modules - screens and cameras, NFC receivers and transmitters. Limitations: higher cost and administration complexity, additional activities must be taken by the visitor before he could use the system. The process of attendance monitoring is following:

1. There are barcodes, RFID, NFC or any other type of physical scanners/readers inside and/or outside the rooms in the building. Each visitor has his own visitor id card (tag, device, etc.), compatible with these readers.
2. Each visitor scans his identification code on the entrance and/or on exit of the room.
3. The moderator receives the information on the visitors in the corporate information system.

Approach F2:

This approach is common at schools. One of the students collects the information on absent students and transfers it to the teacher. Nevertheless, it can be used for other business cases. The limitations for this approach are: the event should be held in place, the visitors group is relatively small and has permanent members, and the supervisor knows every member of the group in person.

1. The role of supervisor is assigned to one of the visitors in the group. This visitor is responsible for monitoring the present and the absent guests.
2. The moderator asks the supervisor for the present or the absent visitors at the start of the event or after the event is finished.
3. Supervisor gives the information on the attended visitors.

Approach F3:

This is one of the conventional approaches in many fields: education (students receive the list with the names of the whole group), community meetings and voting processes (members of the community put their sign next to his name to approve their attendance at the meeting), etc. Limitation: the group members structure is relatively static; the moderator is responsible for collecting the accurate information on the current members before the meeting.

1. The attendance list is given to the visitors in the room (eventually prefilled date, time, subject or any other info regarding the event). The list is prefilled with names of the expected visitors.
2. Each visitor marks the row with his name.
3. After the last visitor fills his info, the list returns to the moderator.

Approach F4:

This is of the conventional approaches in many fields. It is often used to overcome the limitations of the "F3" approach. It can be used for the groups with dynamic structure, allowing to track even unexpected visitors, it can be initiated at the time of the event (no additional preparation is required). It can be used for logging purposes in situations where the access to some shared resource needs to be organized (every visitor leaves his record, when using that shared resource). Limitations: the process of the collection is longer than in F3, transferring the records from the sheet to the system requires more time, the moderator could meet issues with recognizing the text written by hand by some of the visitors; issues regarding identification of the people in the list.

1. A blank sheet is given to the visitors in the room (eventually with prefilled date, time, visitors group, subject or any other info regarding the event). The list of visitors is empty at the start.
2. Each visitor appends a row manually, filling his name and visitor's identification number.
3. After the last visitor fills his info, the list returns to the moderator.

Approach F5:

This approach is a close alternative to the "F1" approach. Though the biometrics-based monitoring systems are popular, only 2% of them are used in the educational field (German and Barber, 2018). It has some advantages regarding security and accuracy compared to RFID technology- the visitor identification code cannot be easily transferred to another person (in contrast to RFID card, for instance). Limitations: privacy issues, security issues are lower than with RFID, but are still present, complexity, cost, additional specific requirements could be assigned by local authorities regarding storing and processing biometrics information. Koshyk, C. (2020) provides a case study of using an application "Face ID" for face recognition and attendance tracking in Japan, at The Kyoto College of Graduate Studies for Informatics. The limitation of the system was that some of the students had no cameras on their work devices as well as bandwidth limitations had caused inaccuracy in the attendance tracking.

1. The organization uses biometric information of the visitors (face detection, fingerprints, voice, etc.) to monitor their attendance at the events.
2. Each visitor leaves his biometric information on entrance and/or on exit using installed scanners or applications.
3. The moderator receives the information on the visitors in the corporate information system.

Group 2. Attendance monitoring approaches for online events

Approach F6:

This approach is the online adoption of conventional approaches. Limitations: inaccuracy, in case the visitors do not describe their names according to the moderator's expectations (only emails are shown, the visitor is using an account of another person, multiple users use one group account, using nicknames instead of real names, one visitor has multiple devices connected to the room, etc.). Moderators could overcome some of the limitations via strict discipline of logging and visitors naming, additional requirements or separate accounts for the visitors, etc.

1. The moderator and the visitors use an online meeting platform.
2. The moderator copies the list of guests from the video conferencing platform
3. Moderator gets the information on usernames, which visitors used.

Approach F7:

This approach is the online adoption of conventional approaches (similar to "F4"). It overcomes some of the issues of the "F6" approach. It has common limitations as in the conventional approaches regarding speed, authentication (connecting the names with the identities)

1. The moderator and the visitors use an online meeting platform.

2. The moderator asks the visitors to send their names or other identification info via public or private chat. The visitors share required information.
3. Moderator collects the information from the chat window.

Approach F8:

This approach relies on the API (application program interface) of the popular video-conferencing platforms. Limitations: the systems require active accounts to use the platforms, issues caused by unstable bandwidth, visitors may use accounts that cannot be directly associated with the expected guests (group account, default account at the computer while using the device of another person, etc.)

1. The moderator and the visitors use online meeting platform, that allow integrating custom modules (i.e. Zoom, Microsoft Teams, Google Meet, etc.). The moderator activates an activity monitoring module from his profile.
2. After establishing the connection with the online event, the module automatically collects information about attendance of the guests (usually emails only).
3. The moderator gets the information on accounts of guests from the generated page.

Group 2. Attendance monitoring approaches for both online and offline events

Approach F9:

This system requires the organization to be the administrator of custom software. Limitations: compatibility issues, computer-oriented events, higher complexity, additional activities to add new users.

1. Each visitor has a computer which contains software that communicates with the company attendance system.
2. After establishing the connection with the online event, the visitor marks his attendance in the software.
3. The moderator receives the information on the visitors in the digital system of the company.

Approach F10:

This approach has been used by the author in a pilot project. It has been tested for a number of courses. Limitations: 3-rd party platform out of control of the organization (privacy issues), vulnerabilities – can be sent remotely without attending the event, requires each team to create forms for each course (time costs).

1. The moderator creates the form for responses in a survey administration software (i.e. Google Forms)
2. The moderator shares the public link online and/or on-place to the visitors. The visitors fill and submit the form
3. The moderator gets the information from the form or connected spreadsheet.

Approach F11:

Limitations: complexity, cost, additional activities for adding new permanent users or guests, lock-in system (attendance outside the platform will not be counted)

1. There is an online platform administered by the company. Each visitor has his own account in this system.
2. Each visitor enters his account. The entrance action transfers automatically to the attendance system or after manual input by the user.
3. The moderator receives the information on the visitors in the digital system of the company.

Features and additional options:

The listed features do not represent the ultimate list of the features in existing attendance tracking systems. Nevertheless, they can be used as a starting point for comparing different systems considering the choice of applicable system for a particular organization. They can also give basic information regarding the performance of a mix of the approaches, which could cover the needs of the organization for a particular type of events.

Limits on entries count

- One entry limit. The system rejects additional entries from the same member or device.
- Multiple entries. The system accepts any number of entries from the same member or device (i.e. the supervisor fills the records for all guests by himself / from one device)

Verification oriented limits

- Anonymous access. The system counts the guests and returns the total number, but doesn't collect information on the guests' identities.
- Out of system users access. Users can apply the form without being a signed user of the service or permanent member of the organization.
- Access for verified users only. The system allows only signed users with permissions for applying the form.

Time oriented limits

- Time limit for entries. The moderator can open and close the system to receive entries from the guests.
- 24/7 self-service for visitors. Visitors can apply the form outside particular time ranges (i.e. when they watch the record of the event, when they decide to access the resource).
- Planning the access time window. The moderator can schedule the opening and closing of the attendance form.

Search functionality and fields validation

- Validation of the fields. The system prevents entering unexpected data in the form (i.e. entering text into the phone number field).
- Error-proof. The system checks for incorrect data or retrieves the needed information from its database.
- Providing additional information. The system provides additional information on the visitor to the moderator (i.e. the system can show detailed information and statistics on the visitors based on the signed identities).
- Search and help functionalities. The system helps visitors and moderators to enter the right information.

Internet dependency and connectivity

- No internet. The system is able to receive attendance information without internet access.
- No electricity. The system is able to receive attendance information without electricity supplement.
- Online events. The system can be accessed through internet (used by online guests)
- Face-to-face. The system can be accessed if the guest is physically located at the event.
- Mixed (online + offline) events. The system can be accessed both by guests at the event and online guests.

Accessibility

- Visual disabilities. The attendance form can be accessed by people with visual disabilities.
- Hearing disabilities. The attendance form can be accessed by people with hearing disabilities.

Current status monitoring
- Exit monitoring. The system is able to track the visitors who exit the event.

0 - unavailable by design. Activation of the feature is impossible / too complex / requires too many trade-offs.
1 - the feature may exist in a particular system, but it would have a very poor performance. In rare cases it could cover basic needs by using additional tools.
2 - depends on the system's realization. Some of the tracking systems can offer the feature by design, but in most cases, it is unavailable, or requires additional activities for its integration. May have unstable results. Requires additional tools.
3 - the feature is available in most of the systems of this type. Very likely to be accessible or have the possibility to be activated by the users. The feature has relatively good performance and covers the basic needs with little or no use of additional tools. Still may require some time for preparation (hard to accomplish within limited time).
4 - The feature is integrated by design (or the feature is needless in the system). The performance of the feature is high. It could cover the needs without using additional tools.

Complexity and time consumption
- Initial developing the system
- Training a moderator to work for the first time.
- Initial preparing the attendance form for an event
- Preparing the attendance form for reuse on the repeating events
- Editing/correcting the prepared form
- Filling the attendance form by a visitor
- Process entries in parallel
- Processing received information by moderator
- Adding new permanent visitor
- Adding new guest visitor to the list

0 - very slow. Requires significant resources to achieve, or a long time to set up.
1 - slow. Requires additional resources to achieve, may cover the feature partially and/or have unstable results
2 - depends on the type of system. Requires some additional activities from the moderator or/and the visitor. May require additional costs, experiments and resources in the first run. May have unstable results.
3 - fast and easy. Likely to be integrated in the system by design. Works relatively fast. In some scenarios may be missing due to some excluded options by design. May need some time for preparation (hard to accomplish in the time of the event)
4 - very fast and very easy / integrated or needless by design

RESULTS

The assessment provides a base for the custom weighted estimations in specific situations. As there are no specific weights given, some overall conclusions could be made independently of eventual priorities. The results of the assessment are shown on Table 2 and Table 3.

Three of the listed approaches are applicable by design with both online and face-to-face events (F9, F10 and F11). One more approach (F5) could be used for mixed events in specific conditions - the information on the visitor's biometrics should be received and processed by the system through the internet (i.e. face recognition based on the image received from the visitor's web-camera). It means that the organizations would probably have to manage more than one approach in order to track the attendance in both online and face-to-face events.

Five of the listed approaches are able to cover the situation in which unregistered visitors can attend the event (based on "Add new guest visitor" complexity). Two of them could give more

detailed information on the visitors, collecting the needed information directly at the time of the event (based on "out-of-system visitors access" feature). Others would require additional activities regarding managing access for the expected guests. Some of the listed methods provide tracking of anonymous visitors, which could share their identity by their will. Though the moderator would receive mainly anonymized or non-proved information on the visitors, this information could provide valuable information for the moderators (i.e. statistics on events the visitors are most interested in).

Table 2. Assessment of features and additional options

Options\Scenarios	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**
One entry limit	4	4	0	0	4	4	4	4	4	4	4
Multiple entries	0	4	4	4	0	1	4	0	0	4	2
Entry as anonymous	0	0	0	4	0	1	1	0	0	4	2
Out of system users	0	0	2	4	0	1	1	0	0	4	0
Verified users only	4	4	0	1	4	2	2	4	4	4	4
Time limits for entries	4	4	4	4	4	4	4	4	4	4	4
Unlimited time for entries	4	4	0	1	4	0	2	0	4	4	4
Access scheduling	4	4	4	4	4	4	2	0	4	1	4
Data validation	4	4	4	0	4	0	0	4	4	4	4
Error proof	4	1	1	0	4	3	1	4	4	1	4
Full info	4	3	4	3	4	0	1	0	4	2	4
Filling help/search	4	0	0	0	4	0	0	4	4	1	4
No Internet conditions	2	4	4	4	2	0	0	0	0	0	2
No Electricity conditions	0	4	4	4	0	0	1	0	0	1	0
Online events	0	2	0	0	3	4	4	4	4	4	4
Offline events	4	4	4	4	4	1	1	1	3	4	4
Mixed events	1	1	1	1	3	1	1	1	4	4	4
Visual disabilities	4	4	0	0	4	4	3	4	4	3	2
Hear disabilities	4	4	4	4	4	4	3	4	4	4	4
Exit control	4	3	1	1	3	3	0	4	4	0	1

Table 3. Complexity and resource requirements for attendance monitoring approaches.

Options\Scenarios	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**
Developing the system	0	4	3	4	0	4	4	1	0	4	0
Training new moderator	3	4	3	4	2	4	4	1	3	2	2
Making initial form	2	2	3	4	0	4	4	1	4	2	2
Reusing the form	4	2	4	4	4	4	4	2	4	4	4
Editing the form content	0	2	2	4	1	0	4	0	1	3	0

Entry by a visitor	4	2	4	2	4	4	2	4	4	4	4
Processing by moderator	4	2	3	2	4	2	2	2	4	3	4
Add new permanent user	3	3	3	4	2	4	4	4	2	3	3
Add new guest visitor	2	1	1	4	1	4	4	4	2	4	3

DISCUSSION

There are much more than 11 approaches for attendance tracking. Some of them are ignored in this article for being too specific to be compared with other approaches:

- extracting the identities of the visitors from video records of the event;
- the moderator fills attended visitors from his memory;
- no attendance monitoring;
- attendance is not assigned to the meetings, but rather to the tasks. After the task is done the guest is checked as attended (or receives the amount of time in his profile, given as a reward for this task);
- participants make self-reporting.

The article is focused on the two phases of attendance monitoring: collecting attendance information and transferring the collected information into the information system of the organization. It does not cover other phases (i.e. storing the information, analysis, etc.). The vulnerabilities of the approaches are not in the focus of this assessment.
The points received by the approaches represent the common level of performance of the systems in the group. One particular system could include or exclude specific features. Thus, additional analysis should be made in case of comparing particular systems from different groups.

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