# IDAC: A Sensor-based Model for Presence Control and Idleness Detection in Brazilian Companies

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Keywords: Location-awareness, Sensor Networks, Social Implications for IoT, Idleness Detection, Presence Control.

Abstract: This article proposes a new model named IDAC for idleness detection and automatic clocking in Brazilian companies. Based on the studies and the gaps identified in related work, we highlight the model features and how it interacts with sensors, providing idleness detection based on the historical movement of the employees. We developed a prototype that was evaluated through simulation, taking into account the architectural plant and the employees behavior of five real Brazilian companies. The results reveals the benefits of using IDAC both at the owner (control and productivity) and employees (the clocking actions occurs automatically) levels.

## 1 INTRODUCTION

Today, we perceive the growing adoption of the Internet of Things (IoT), where RFID (Radio-Frequency Identification) appears as the most used sensor technology to turn IoT into a reality (Ryu et al., 2013). RFID is a wireless identification technology that can locate physical objects and connect them to the virtual world, allowing various applications, as the mobile payment systems (Pedraza et al., 2010). In general, the RFID technology is commonly employed in context awareness or presenting the location and information of objects precisely. Hence, through an information management system composed by historical data of each object, we can interact with them in order to solve or minimize problematic situations of our daily activities (Atzori et al., 2010; Narzt et al., 2015).

Among the various situations of our daily lives that can be optimized using context-awareness, one of them is the clocking (Akkaya et al., 2015). In this context, the most used technologies are paper-based card-points and magnetic card-peer systems. Moreover, some companies use safer technologies, including biometric recognition and others work based on the recording of entry and exit times by hand on a time-sheet (Pereira, 2012). As a common feature, all these forms depend on the employee decision to clock in. They are not automated and if the employee forget to clock in or out, his/her point-sheet remains incomplete. Furthermore, the usual point-sheet payroll system allows the manager to know when the employee entered and left the company, but may not identify how this time interval is being spent by the employee: he/she may take long breaks, which may be frequent. In a company with hundreds or thousands of employees, it is virtually impossible to identify how productive the time spent by the employees at the company actually is.

We witness how hard the manager's task of controlling the working ours of the employees can be. Relying solely on the judgment of the manager to decide about both idleness and activity of its employees without any form of registration becomes a risky task, with great chances of occasioning assessment errors. Having identified this problem, we developed a model named IDAC: a context-awareness model to both control presence and detect idleness using sensors to indicate the movement of employees within the environment of Brazilian companies. The IDAC's idea is to allow not only to control entry and exit times, but also to view, using a management tool, how much time each employee spent on each of the company's areas. In this way, the manager can assess how long they are active on their desk and how long they are idle, out of their workplace or in recreation areas for instance. The IDAC's scientific contribution is emphasized on its algorithm and framework for detecting idleness: based on a set of rules that can be changed dynamically, being able to identify situations that differ from what the managers expect.



Righi, R., Rostirolla, G., Reis, E., Fischer, G., Chang, V. and Ramachandran, M.
IDAC: A Sensor-based Model for Presence Control and Idleness Detection in Brazilian Companies.
DOI: 10.5220/0005954304790486
In *Proceedings of the International Conference on Internet of Things and Big Data (IoTBD 2016)*, pages 479-486
ISBN: 978-989-758-183-0

The remainder of this article will first present the related work in Section 2, the IDAC model in Section 3, the evaluation methodology in Section 4 and finally, the results and conclusion in Sections 5 and 6 respectively.

## 2 RELATED WORK

Based on the research theme, related works that solve similar problems, or can be used as a base for possible solution attempts, were analyzed. The evaluated works are presented in Table 1, which shows the features, based on defined criteria, for each one of the approaches.

Table 1: Comparative Table between Related Work.

| Work | Technologies | Passage Record | Identify Location | Idleness Detection |
|---|---|---|---|---|
| (Neiva, 2012) | RFID | No | Current | No |
| (Pereira, 2012) | RFID and Biometrics | Incoming and outgoing | No | No |
| (Ahgora, 2015) | RFID and Biometrics | Incoming and outgoing | No | No |
| (CH&TCR, 2015) | RFID | Incoming and outgoing | Current and traveled route | No |

There are currently an increasing number of trends aiming to generate people records using the RFID technology, although there are not so many trends when the subject is the clocking systems. Considering the analyzed works we can notice that it is possible to use technology to record not only the time spent by employees in companies, but also generate an accurate record of the passages of these employees through internal environments.

Based on the current state of the art and the gaps identified in related work, one can see that it is possible to perform electronic time-card records using the RFID technology, as well as identify the location of a person within an environment. However, many of the approaches are still based on the employee's conscious choice to record his presence using a tag in a reader, not exploiting the capacity of automatizing this process. Also, most approaches do not seem to go deep enough to identify where are the staff members after the registration and who can identify their location do not use these data in order to identify possible idleness patterns. Considering the aforementioned gaps, this article presents the IDAC model for Presence Control and Idleness Detection inside Brazilian companies.

## 3 IDAC: IDLENESS DETECTION AND AUTOMATIC CLOCKING

IDAC aims to identify the entry and exit of employees automatically using RFID technology, creating an accurate and consistent point-sheet record. It also identify where employees are within the company's environment and analyze these data in order to realize when they are idle. The model assumes that there are RFID readers scattered throughout the company environment, which can identify employees who pass by them. Each employee must have a tag that enables the system to identify him and carry it with him through their whole shift, furthermore, this tag must be linked to a specific job by the employer.

The operation is based on the ability to schedule the arrival and exit of each employee at the company's environment and register it in the point-sheet, generating reliable markings for the workday. It should also record all the passages of employees through business environments, so that whenever an employee stays more than a certain time away from their workstations, the system is able to identify and store this information. Moreover, it identifies when groups of two or more employees are out of their jobs, characterizing a grouping, and when an employee receives a visit of others at his workstation.

The IDAC system is divided into five modules, they are responsible for processing information from its capture by the RFID reader to the final result, which is displayed to the employees and managers through a web application. Figure 1 presents the framework proposed for the IDAC model and its modules are described below.

**IDAC_CaptureRFID** is the module responsible for receiving the data captured by RFID readers and store it on the database. This step does not perform any processing on the information. Thus, three information are stored in the database for each capture: the read tag's identifier, a timestamp and the reader identifier. The final result is stored as *Raw Data*, since it is the main entrance of data into the system, this module must be able to capture information very quickly, avoiding bottlenecks, so no further processing is applied, ensuring that the information is persisted as soon as possible.

**IDAC_Formatter** is the module responsible for performing the pre-processing of the *Raw Data*. At this stage, the employee that owns the tag and the sensor that read it are identified through the identifiers. If

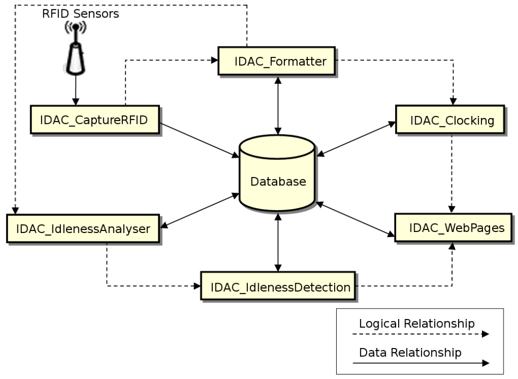


Figure 1: Framework IDAC. The logical relationship refers to the data path between the modules, from data readings by sensors until information visualization in the WebPages module. The data relationship application refers to the actual course of the system data. No module communicates directly with another module, communication is always carried out through the database.

it is a time-card sensor, it creates a *Clocking Marking*, otherwise it is instantiated as a *Passing by Marking* and the final result is stored in the database. Since it is a module that searches and makes a pre-processing of the information, it runs the whole time on background, waiting for the arrival of new *Raw Data*. If a very large batch arrives all at once, the system will compute little by little, avoiding overloads in the application.

**IDAC_Clocking** is the module responsible for performing the processing of the type *Clocking Marking* and *Forced Marking*. At this stage, a new type of data is created *Worked Day*, which will store all markings, forced or not, in a list based on the data and the employee to which they belongs. After processing all the marks received during the day, all data of the type *Worked Day* is computed by identifying peers, adding the time worked and storing this information. In case of extra events such as: Notifications, Overtime or Negative Time, data of same type is created and stored in the database.

**IDAC_IdlenessAnalyser** is the module responsible for performing the processing of the data type *Passing by Marking*. At this stage, the passage of the Employees through the company's environments are identified. Each pair of markers identifies the exit from a place and the arrival into another and a new data type called *Pass* is created. It stores the place that the employee has been to, time spent in this place and who is the employee.

**IDAC_IdlenessDetection** is the module responsible for identifying the idleness of employees. It is executed at the end of the day, after all appointments have been processed and turned into passage records. Based on the data type *Pass*, the workday of each employee is processed. This module identifies where the employee has been too and his shift, as well as time spent in each environment. Thus, if it is detected that an employee has exceeded the stay time limit set by the Manager, not complied with the minimum of daily activity or was part of a grouping, the system identify a idleness behavior. Furthermore, it is stored in the database as a new type called *Idleness*.

**IDAC_WebPages** is the view layer of all the information processed by the other application's modules. This is the module that allow the *Forced Markings* to be included, overtime to be justified and markings/*Idleness* to be viewed. It is the second input of data for the application, but unlike the capture module, where information is received automatically, this data is entered by users.

Information flow in the system starts from the IDAC_CaptureRFID module that receives the records captured by RFID readers. Thus, the information travels to IDAC_Formatter module that produces two new treatment flows: in one of them, the data is sent to the IDAC_Clocking module that performs the decision-making and delivers it to IDAC_WebPages, the other data stream is sent to the IDAC_IdlenessAnalyser module. After, the information travels to IDAC_IdlenessDetection module, which performs a new set of decision-making in order to send processed data to be displayed in the IDAC_WebPages.

Currently, the IDAC system is available with two types of actors, the Manager and the Employee. Each one has responsibilities and interests that are relevant to the model proposed here, besides specific access rules. Manager is the user responsible for the administration, he has the obligation to register a tag for each of his employees and guide them to carry it throughout the working hours. This actor must have access to the markings of all employees, be able to justify all situations that escape the normal workday, make markings manually and validate justifications and markings recorded by employees. Employee is the main user of the system, he must have his markings automatically registered and have investigated his idleness. Thus, he has the obligation to carry with him a tag (RFID wristband) for identification.

In addition to actors, the system have three main features, the first one is responsible for idleness detection, the second for the clocking markings and the last is a management tool. These features are described in details below:

### 3.1 Idleness Detection

To perform idleness detection the system must have the following features: (I) Inclusion of Places; (II) Sensors Inclusion; (III) Passage Registration; (IV) Insertion of Event Logs; (V) Idleness Detection Core; (VI) Detection of Groupings. In functionality (I), based on the company's building, each of its environments (rooms or departments) can be included as a place and a type must be chosen for this place, which can be a kitchen, restroom, meeting room, workstation, corridor, recreation room, warehouse or spare room. Functionality (II) allows RFID readers to be linked to the companies environments, reading the employee's location and gathering information that can be used by the passage registration system. The functionality (III) is responsible for whenever an employee passes by a sensor, the system checks which place the sensor belongs to and stores both the time and position in the database.

The functionality (IV) allows to add a log if there are situations where the employee must be out of his/her workstation (for a meeting, for example), so not characterizing an idleness situation. The functionality (V) assumes that whenever the system identify an employee out of his workstation for longer than the time limit, must register a possible idleness in the system. Finally, the functionality (VI) assumes that whenever the system detects a stationary employee out of his workstation for longer than the time limit, you should check whether there are other employees in the same place. When detected the existence of two or more employees in the same place for longer than the time limit set, the system starts to record the possible grouping in the database, giving information about the place, duration and employees.

The idleness detection algorithm starts at the end of each working day. After the processing of all employees by the IDAC_IdlenessAnalyser module, it does a search in the database to see if there is any record of a *Pass* that has not been processed, these records consists of: place, employee, incoming, outgoing, elapsed time and a flag that defines if it has been processed or not. If all the markings have already been processed, the system stays in standby state and repeats the procedure after a certain period of time, but, if there is an unprocessed *Pass* marking, the system gets the employee information and gathers all his markings for that working day, sorting by the incoming time. With all the employee's *Pass* markings, the system starts a time counter that stores how long the employee was out of his working station, so this counter is incremented based on the difference between the incoming and outgoing timestamps. The algorithm goes into a loop that runs through the list calculating the idleness period for all the *Pass* markings in which the employee was out of his working station. The minimum time interval for which the pass is considered idleness is defined by the *Manager*.

The process of verification of groupings consists in the search for the passages of an employee for a certain environment that has last longer than defined by the *Manager*. If the employee has a passage over the time set as the minimum to check for groupings, the system searches for registered groupings at that time and place. If there is a grouping record, the employee is registered as a participant of that group, otherwise it searches in the database for other employees who reported idleness in the same place and time, if positive a new grouping record is created and both employees are recorded.

### 3.2 Clocking Markings

For the system to perform clocking, it must have the following features: Insertion of Marking Sensors (I); Clocking record (II); Lunch Time Validation (III); Time validation (IV); Extra and Negative Time Record (V); Record Checking (VI); The functionality (I) allows, based on loaded Places, RFID readers to be linked to one of the possible entrances of the company, in order to record the entry and exit of employees. The functionality (II) assumes that whenever an employee go through a marking sensor (a tag is read by a reader), the system must store the time information in the database as a *Clocking Marking*.

The functionality (III) assumes that at the end of the workday the system should analyze how the employee spent his time in order to find longer than an hour and less than two hours intervals and treat them as lunch breaks. Functionality (IV) states that at the end of the day the system should add the time spent at the company for an employee in order to get actually worked time. Functionality (V), the system after the marking and sum of total work time, check the incidence of extra or negative hours of the employee, recording it separately to enable the manager to treat it correctly. The functionality (VI) assumes that the application should be able to show the markings of employees for themselves and, if there is any incorrect information, they can force a manual clocking marking (*Forced Marking*) describing a justification for it.

### 3.3 Management Tool

For the employees, the management tool should be able to display the registered *Clocking Markings*, allowing the inclusion of markings under justification, which should wait as "pending" validation. The employee must be able to view the extra and negative hours too, allowing the inclusion of justifications, which shall also wait for validation. As for the managers, the management tool should be able to display the clocking markings recorded for all the employees, defining the pairs, besides allowing the inclusion and exclusion of markings and the validation of the inclusion justifications referred by their employees.

In order to evaluate the model, we implemented the IDAC_WebPages application, covering all the features on the Management Tools for both Managers and Employees, and the modules described on Figure 1. However, all features related to insertion and maintenance of Places and Sensors, based on a visual representation of the business building plan were not implemented. These features are not considered important for data collection, nor for further analysis through simulation.

# 4 EVALUATION METHODOLOGY

To evaluate the IDAC system, it was decided that it would be interesting to use two different approaches. Thus the assessment methodology will be through a quantitative analysis of the system, with two test trends. The first will be the functionality tests, where the system would run tests for a given scenario and collect the application's results for a theoretical group of employees. Hence, being able to display the information that will be available to the managers if the system was running on a real company. The application timeouts have been defined by the management of the shirts making company. The second approach would be through a stress test in order to verify the limits on the load of the application that process information. In addition, the tests should check the correlation between the run-time interface and the data to be handled. Finally, identify the maximum number of markings that the system is capable of processing without generating a processing queue.

In order to enable the proposed approaches, a test was previously developed and loaded on a theoretical business environment system (Figure 2). In this company there are 17 distinct environments, each of which is characterized as one of the possible places where the system is prepared to apply specific rules in order to detect idleness. The group of employees was randomly generated and distributed among the available workplaces.

To test the application, a simulator was developed, capable of reproducing the result that would come

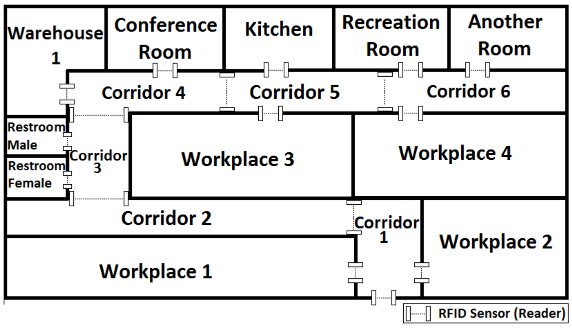


Figure 2: Theoretical plant used in the tests.

from a functional capture module. This simulator main function is constructing a path to be followed by a theoretical employee in a working day of the simulated company. After being decided whether the employee will meet the minimum production time or not, it is set the total period that he will remain idle during that working day. Later, it determines how long the employee will go for lunch that day, which may be within the limit set by the law, or not.

Then the simulator enters a loop that defines the employee's activity. If the employee spend more than half the time set at the beginning of simulation in either working or idle state, the simulator force him to fulfill the opposite scenario. Once the developer's time counter cross the half of the theoretical day, the system sends that employee to lunch for as long as it was previously defined. Upon returning from lunch, again a random numbers generator defines a new path to be followed. When the working time counter reaches the day limit, the theoretical employee leaves the company.

All the places to which the employee must go are stored in a queue and processed immediately, so they go through the shortest path from one place to another, using the *Dijkstra* algorithm. After the final path is finished, as well as all the intermediate places, it is enqueued in a new queue and waits to become markings. After all employees' working days are defined, through simulations, the simulator starts to load the database. It started simulation clock and as it is incremented, the situations stored in the queues of each employee are effectively included in the database. Thus, the simulation is closer to reality, since first it processes everything that happens, at any given time, for all the employees, not the whole day of each employee sequentially. The simulation clock increases ten seconds per iteration.

Survey data for analysis was gathered through simulations performed for lots of employees, based on staves of real companies. The numbers were raised based on the Ranking "Great Places to Work", which is managed by the institute[1]. Thus, five plants have been used as examples: Molas Weber manufacture of springs, which typically employs 80 employees; Perkins Engines manufacture of diesel engines, which has 143 employees; Zanzini furniture manufacturing of furniture, which has a staff of 356 employees; Jost Brazil auto parts, a manufacturing industry for trucks, trailers and semi-trailers, which employs 400 employees; And finally, the Portas Pormade, doors manufacture, which has 482 employees.

# 5 RESULTS

For each batch of employees, based on the aforementioned companies, the simulation and the IDAC system were executed in order to view the results generated by the application. For each simulation, a results page was generated by the Web Pages application, bringing information such as number of employees at the test environment; amount of idleness records; percentage of employees who had some idle record; amount and percentage of employees who failed to meet the minimum daily activity; amount of detected groupings and the main environment in which those occurred; peak time for idleness and grouping; number of employees who have not fulfilled the lunch time; total overtime generated; and number of employees that generate this overtime.

## 5.1 Experiment 1: 80 Employees Simulation based on Molas Weber

In a group of 80 employees distributed by the company's environment, a total of 350 idleness records have been identified. Of total employees, 75 (93.75%) had some idle record against five employees (6.25%) who did not have any. 58 employees (72.5%) failed to meet the minimum daily activity. The employee with the highest idleness worked only 405 minutes during the day (84.375% of his working hours). 33 groupings were identified, most of them occurred in the "Restroom Male" environment. The peak of groupings registered at the same time (6) occurred between 15:00 and 15:59. The peak of idleness recorded at the same time (72) occurred between 07:00 and 07:59 (Figure 3). 65 employees did not meet the lunch time given by law. 2 employees generated overtime. The total overtime paid on the day was 0:28 hours.

[1]http://www.greatplacetowork.com.br

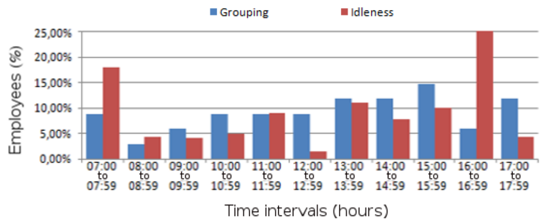


Figure 3: Groupings and idleness through time of experiment 1.

## 5.2 Experiment 2: 143 Employees, based on Perkins Engines

In a group of 143 employees distributed by the company's environment, a total of 652 idleness records were identified. Of total employees, 132 (92.3%) had some idleness record, against 11 employees (7.69%) who did not have any. 111 employees (77.62%) failed to meet the minimum of daily activity. The employee with the highest idleness worked only 405 minutes during the day (84.375% of his working hours). 34 groupings that have taken place mostly in the "Recreation Room" environment were identified. The peak of groupings registered at the same time (5) occurred between 15:00 and 15:59. The peak of idleness recorded at the same time (136) occurred between 16:00 and 16:59 (Figure 4). 42 employees failed to meet the lunch time given by law. 3 employees generated overtime. The total overtime paid on the day was 0:35 hours.

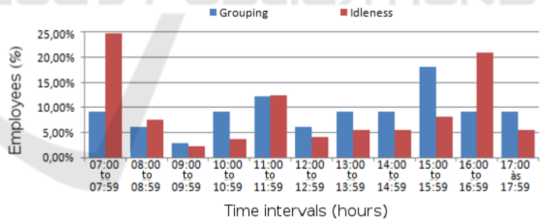


Figure 4: Groupings and idleness through time of experiment 2.

## 5.3 Experiment 3: 356 Employees, based on Zanzini Furniture

In a group of 356 employees distributed by the company's environment, a total of 1607 idleness records could be identified. Of total employees, 320 (89.88%) had some idleness record, with 36 employees (10.11%) working all day without idleness . 270 employees (75.84%) failed to meet the minimum of daily activity. The employee with the highest idleness worked only 405 minutes during the day (84.375% of his working hours). 39 groupings have been identified, which occurred mostly in the "Kitchen" environment. The peak of groupings registered at the same time (5) occurred between 09:00 and 09:59. The peak of idleness recorded at the same time (348) occurred between 16:00 and 16:59 (Figure 5). 115 employees did not meet lunch time given by law. 5 employees generated overtime. The total overtime paid for this day was 1:06 hours.

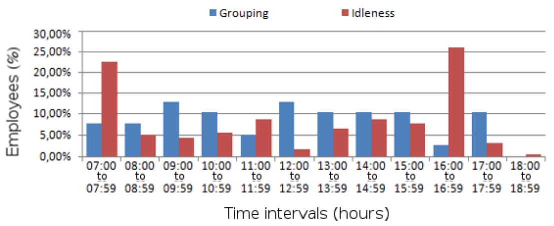


Figure 5: Groups and idleness a function of time of experiment 3.

### 5.4 Experiment 4: 400 Employees, based in Jost Brazil

In a group of 400 employees distributed throughout the company's environment, a total of 1843 idleness records could be identified. Of total employees, 377 (94.25%) had some idleness record, compared to 23 employees (5.75%) who worked all day without any idleness record. 323 employees (80.75%) failed to meet the minimum of daily activity. The employee with the highest idleness worked only 405 minutes during the day (84.375% of his working hours). 34 groupings have taken place mostly in the "Kitchen" environment. The peak groupings registered at the same time (5) occurred between 14:00 and 14:59. The peak idleness recorded at the same time (383) occurred between 16:00 and 16:59 (Figure 6). 130 employees did not respect the time for lunching given by law. 10 employees generated overtime. The total overtime paid for the day was 2:29 hours.

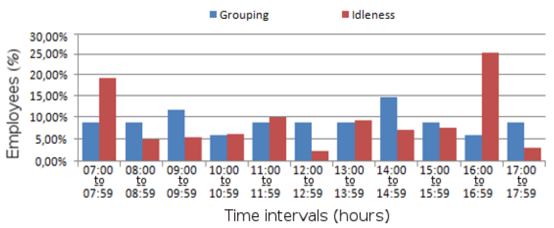


Figure 6: Groups and idleness a function of time of experiment 4.

### 5.5 Experiment 5: 482 Employees based on Portas Pormade

In a group of 482 employees distributed throughout the company's environment, a total of 2178 idleness records were identified. Of total employees, 444 (92.11%) had some idleness record, compared to 38 employees (7.88%) who worked all day without any. 368 employees (76.34%) failed to meet the minimum of daily activity. The employee with the highest idleness worked only 405 minutes in the day (84.375% of his working hours). They identified 36 groupings that occurred mostly in the "Recreation Room" environment. The peak groupings registered at the same time (4) occurred between 09:00 and 09:59. The peak idleness recorded at the same time (513) occurred between 16:00 and 16:59 (Figure 7). 138 employees did not meet the lunch time defined by law. 11 employees generated overtime. The total overtime paid for the day was 2:43 hours.

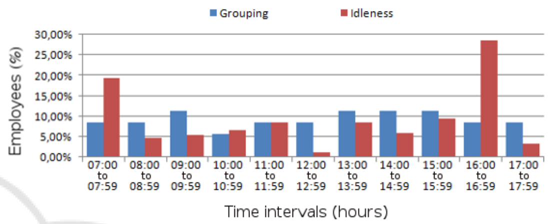


Figure 7: Groups and idleness a function of time of experiment 5.

### 5.6 Performance

In order to analyze the application's performance, execution times were captured, in milliseconds, for the test scenarios of Experiments 1 to 5. In Figure 8 there are graphs relating the expected execution time, calculated from the time raised as the lower case of each module, with the execution time calculated by the simulation.

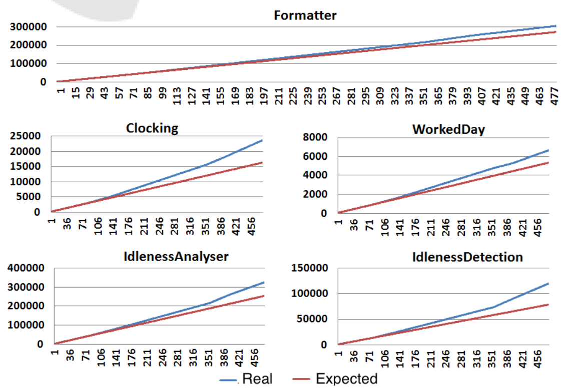


Figure 8: Execution time for the modules responsible for taking decisions on the IDAC system (Employees X Time). The real time refers to the time that has actually been captured by the simulation, while the expected time is only a representation of how the time would be if it were in linear relation to the numbers of employees.

Finally, we performed successive load tests in order to verify the maximum number of records that the application is able to process on an interval of a second. Furthermore, we identify how many employees could go thorough a set of readers, at the same time, without generating processing queues for database inclusions. After testing, we concluded that, on average, the system is able to process 230 markings in a one second interval. Starting from the premise that between one reader and another there is a physical space that each employee takes about ten seconds to cross, the system is able to process the passages of up to 1150 employees in the same time interval.

### 5.7 Discussion

Based on the data collected through tests and simulation, we note that there is evidence of system usability and its ability to perform the clocking, as well as raise all idleness and groupings for the theoretical groups of employees. However, it is important to note that this results can not be generalized. So we can say that a absolute validation of the system would require its implementation in a company's environment.

Regarding performance, in the experiment with the larger number of employees, the application took 13 minutes and 55 seconds to process all the information generated by the simulator. The graphics bring the execution time, depending on the number of employees, slightly above the linear, suggesting that the system has an excellent performance, being able to process even larger batches of employees.

## 6 CONCLUSION

This work presented the IDAC model, which is able to evaluate the markings and the identification of possible idleness (alone or in groupings) of employees in companies. Based on a set of rules that can be changed dynamically, the system is able to identify situations that flee from the managers interests. Been dynamic enables it to adapt to the reality of a wider range of companies. As results, it is emphasized that the system was able to identify the idleness and groupings of theoretical employees for every performed experiment.

As a future work, developing the IDAC_CaptureRFID module is the main objective, in order to have all the proposed model effectively constructed. Also, the Framework decentralization. Therefore, the implementation of a distributed database would be required, so that the modules do not make requests to a single database. Thus, the current limit for the system is database speed, which may increase by several times the application processing capability. Finally, it is expected to implement the system in a real business environment in order to have real data for a better validation of the proposed application.

## ACKNOWLEDGEMENTS

The authors would like to thank to the following Brazilian Agencies: CNPq, CAPES and FAPERGS.

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