UPatras and CEID

The current use case was implemented through a collaboration of the CTI team from IoT Lab with participants from the University of Patras (UPatras). UPatras was founded in the city of Patras, Greece in 1964. The University is a two-city campus, situated both in Patras and Agrinion, Greece. It is the third largest University in Greece regarding the size of student potential, the Faculty Members, Administrative Personnel, number of departments, and accredited student titles. UPatras includes 24 Departments, with a large number of sectors and consequently a great range of disciplines, which operate 112 laboratories and 14 fully equipped clinics. UPatras has 28,727 Undergraduate and 3,959 Postgraduate students, a total of 727 faculty members, 146 Teaching and Technical staff and 457 Administrative Personnel. (data of September 2013). Besides its distinguished path in education, UPatras has excelled in the fields of Basic and Applied Research. It has acquired international prominence for pioneering wide ranging Research in areas such as Environment, Health, Biotechnology, Mechanics, Electronics, Informatics and Basic Science. A number of the Departments, Laboratories and Clinics have been designated as Centres of Excellence, on the basis of International Assessment. The University of Patras has a reputation for quality and innovative research and presents an effective participation in a plethora of Research Projects, Scientific Organizations, and Research Groups. Together with its educational and research work, the rich campus life of UPatras, attracts many candidate students every year as their first and foremost choice for their Higher Degree studies.

More specifically, the participants were staff members of the Computer Engineering and Informatics Department (CEID). CEID was founded in 1979 and is essentially the leading part in the field of Computer Technology, Informatics and Communications in Greece. In a short time, developed into one of the best university departments in Greece with a large number of candidates every year. Involved in teaching and research in science and technology of computers and the study of their applications. The Department provided the CTI team with a specific set of office premises within the building of CEID, as well as access to several smartphones, the users of which served as participants for this use case.

A crowd-enabled scenario for efficient smart energy management

In order to demonstrate the capabilities offered by the IoT Lab platform, we developed a smart energy management scenario that incorporates participatory sensing mechanisms. In this scenario the system tries to optimize the operation of indoor units that consume energy in terms of energy efficiency and user satisfiability via participatory sensing practices. First the participants are incentivised to provide access to their hand-held devices from which data on the ambient environmental conditions are collected and aggregated into live luminance maps. Then, the indoor lighting units and A/C facilities are dynamically adjusted based on the ambient conditions and the feedback provided by the participants to the system on their personal preferences and experienced comfort.

The use case was successfully tested by the cooperation of the Building Manager of University of Patras and CTI’s Engineering team of IoT Lab. The participants were notified of the necessary steps required for their participation in the use case. They downloaded the smartphone app and filled a unique project number given to them by the organisers. The Building Manager proceeded with registering in the platform. He discovered the mobile devices via the use of the project code and registered the lights and location sensors. He also discovered and registered the sensors responsible for the monitoring and actuation of the building. He ran two scenaria, one manual and one automated, with the purpose of comparing the total energy consumption in each, and consequently measure the effectiveness of the IoT Lab platform.

Experimental set-up

The building space was virtually partitioned into 4 areas, each one mapped to an on/off light control unit. Additionally, the experiment controlled a central HVAC unit. The smartphone application was used by 11 participants (students, professors, researchers, all of them agnostic about the system). We ran two scenaria in a span of 6 days each (Tuesday to Sunday). In the first scenario (manual), the system was not operational, and the participants were handling the devices of the room on their own, just like a normal day in the office. In the second scenario (automated), the system was operational and the devices were being operated according to the experiment defined by the Building Manager in the IoT Lab platform. The exact days that the experiments were conducted were 30/8-04/09 / 2016 (manual) and 06-11/09 / 2016 (automated).

The system could locate the participants and their movement within the 4 partitioned areas. Each participant's phone, after he/she accepted to join the experiment, was periodically polled with a frequency of 10 minutes to provide light readings of his/her current location in exchange for some budget defined by the corresponding incentive policy. The budget designed for this use case was the collection of some virtual points. Based on the sensor readings of the smartphones, and the participants' preferred luminance level the lighting of the area was adjusted. Also, their presence triggered the actuation of the HVAC unit. Apart from using the smartphone app for the lights actuation, participants followed their daily office routine.

We used two incentive policies: (i) The Flat Incentive: This is a simple strategy used as a baseline for the evaluation of the other strategies in which the system distributes the available budget over the set of people based on the number of the polled measurements, (ii) Location-aware Incentive: as the system is constantly aware of the location of each person inside the premises, in this strategy, the system distributes the budget based on the number of people in each tile in addition to the number of measurements.

Evaluation of results

For the performance evaluation of the efficiency of the overall system, we utilized several performance metrics that capture different aspects of the IoT and the participatory sensing components of the testbed facility.

Energy Consumption measures the total energy spent by the participants while using the building. Figure 1 shows the energy consumption for the manual and automated use of the premises. The consumption is indicated in groups according to the consumptions of each specific day. The automated scenario performed much better in all days (except one - Wednesday) saving 52% of energy in total. On Wednesday, we notice a larger than normal user participation and activity in the premises. This is apparent in the sharp increase of budget distribution to the participants at that day, as viewed in Figure 5. An interesting remark, is that the automated scenario save energy also during the weekend, when the manual scenario kept some devices open (a participant forgot to close a light).

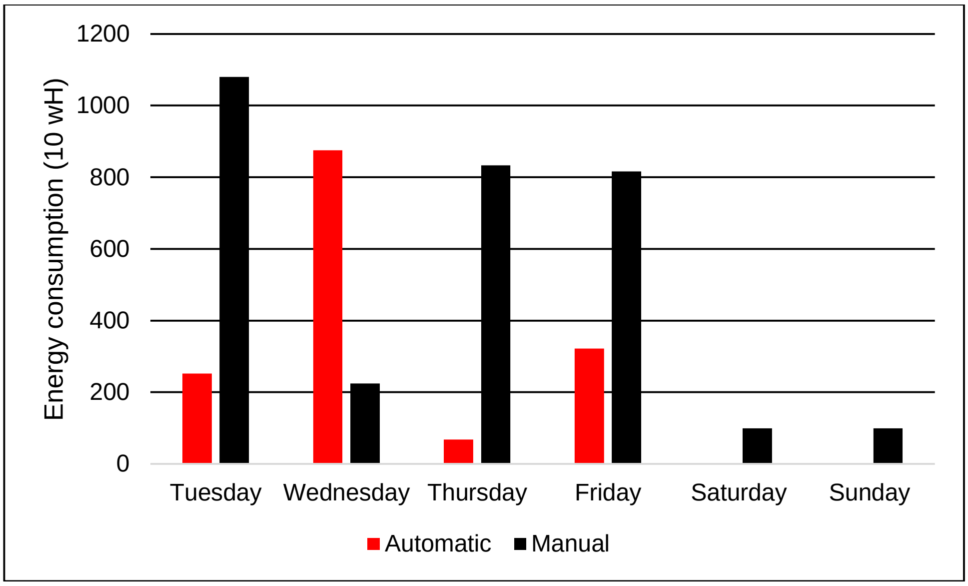

Figure 1: Total energy consumption per day.

User comfort measures the user satisfaction when being in the premises, in terms of lighting conditions. It is evaluated by comparing the light readings from the smartphone devices to the light preference of each participant. Indicatively, we present Figures Figure 2Figure 2Figure 3Figure 4, which depict the readings from three individual participants' smartphones and their corresponding, diverse light preferences. Both participants 1 and 2 achieved a high degree of satisfaction since their light preference was met. The third participants' preference couldn't be met since the scenario considered adequate lighting paramount. Of note are the periods when the light readings are zero. They indicate the participants' nonconformity with the scenario instructions (e.g. putting the phone in the pocket).

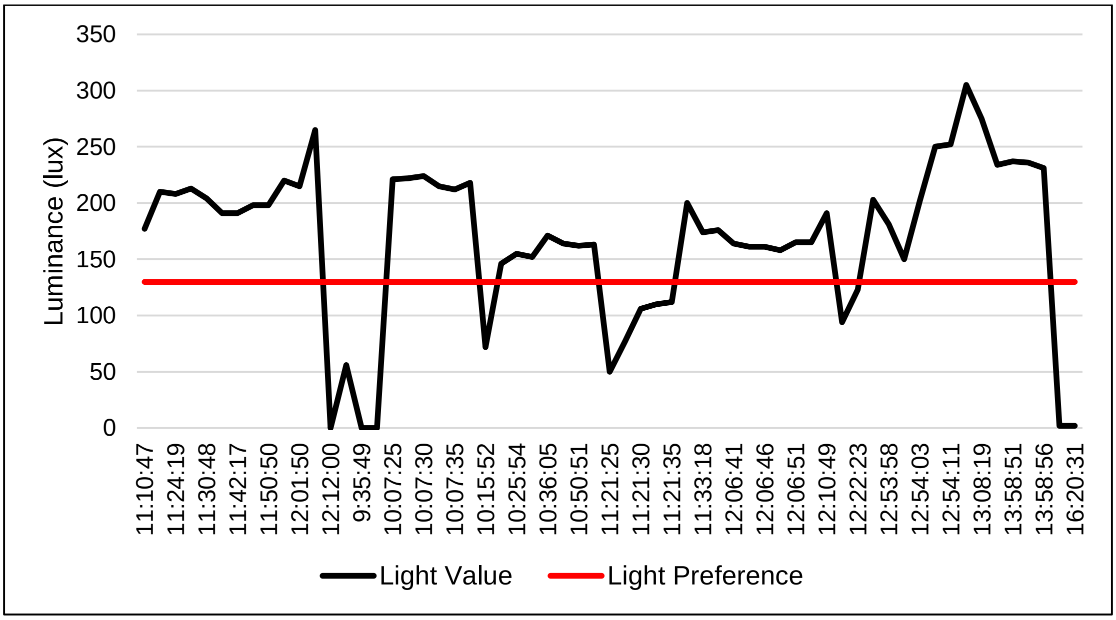

Figure 2: Comfort for Participant 1

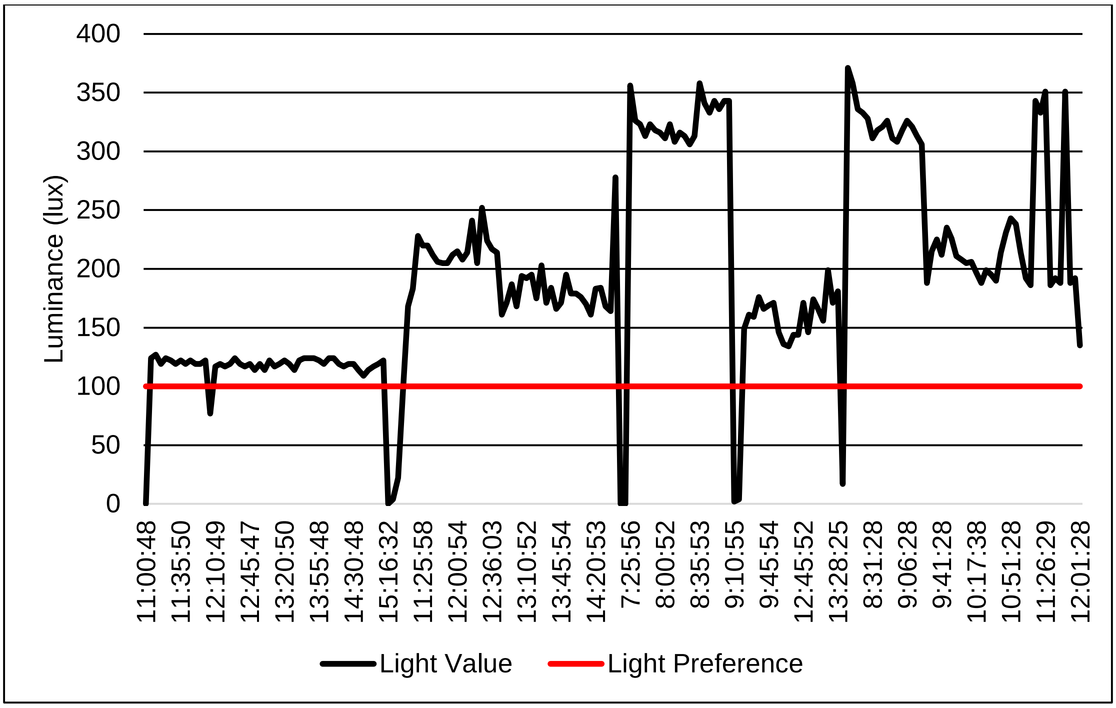

Figure 3: Comfort for Participant 2

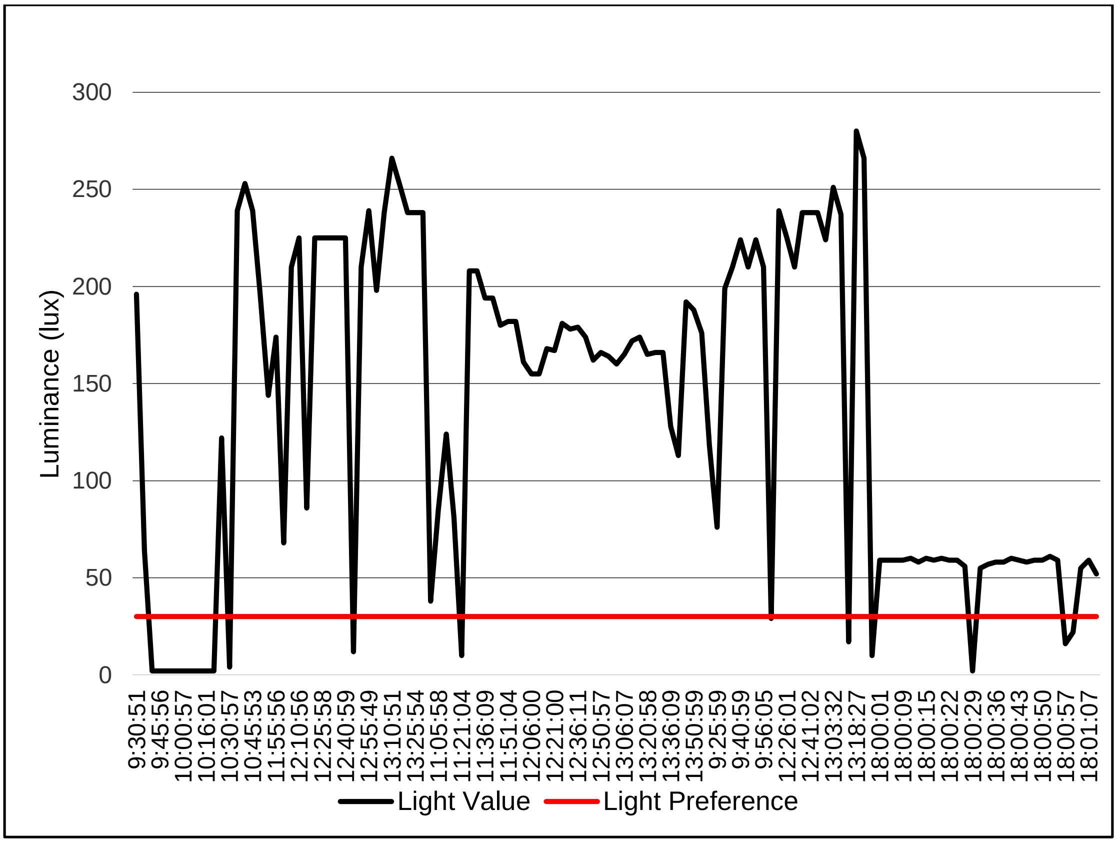

Figure 4: Comfort for Participant 3

Budget spent measures two different budget allocations, according to the incentive policies followed. The location-aware policy proved 8% more efficient over time than the flat one as seen in Figure 5. The intuition behind this result is that the location-aware policy distributes the budget in a smarter way. It revolves around the principle of a rewarding more the scarce tiles in regards to locality measurements rather than offering the same reward to all measurements. For example, if an area I occupied by one participant, the participant will be rewarded with a budget portion of 1. However, if an area is occupied by 4 participants, then each one will be offered a budget portion of 0.25, resulting in a lower budget expenditure.

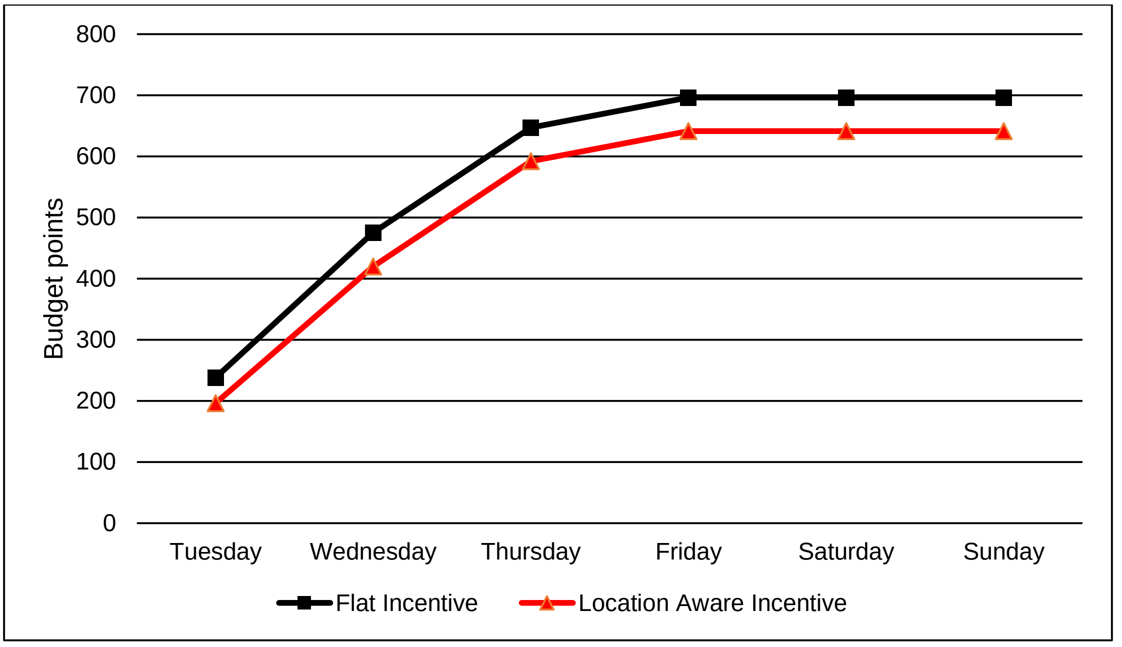

Figure 5: Budget spent over time.