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Shuttle Efficiency Study: The "Owl Express"

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ABSTRACT

Florida Atlantic University first began conducting classes in 1964 in Boca Raton, Florida as an upper-level and graduate school only. Over the years FAU has grown and opened its enrollment to full undergraduate and graduate programs housing 10 colleges and 170 degree programs. With the growth and scope of the university programs increasing over the years, student enrollment has exponentially increased since the schools inception. With the increasing growth of the campus and student body, increasing strain to the traffic and parking conditions have occurred.

The parking issue came to the forefront of university issues at the beginning of the fall semester in 2009. The current ratio of number of students/parking spaces on campus is approximately 2/1 and does not include faculty, staff, and visitors.The university has implemented a shuttle system to encourage the use of remote access parking, and to reduce congestion on the campus. The intent of this project is to evaluate and make recommendations for the Florida Atlantic University shuttle system. The scope of this study is to review the current shuttle system, and make recommendations on optimizing the shuttle network for the Boca Raton campus for travel time, efficiency, and safety.

Keywords: Route optimization, shuttle scheduling, micro-simulation, stop location

1. INTRODUCTION

Florida Atlantic University first began classes conducting classes in 1964 in Boca Raton Florida as an upper-level and graduate school only. The Boca Raton campus was initially converted from a World War II air and radar base that was closed after the war. Over the years Florida Atlantic University (FAU) has grown and opened its enrollment to full undergraduate and graduate programs housing 10 colleges and 170 degree programs. FAU has several campuses, with the main campus located in Boca Raton.

With the growth and scope of the university programs increasing over the years, student enrollment has exponential increased since the schools inception. The first year FAU had open enrollment, only 1,000 students registered for classes. In contrast the enrollment for the Boca Raton campus in 2009 was over 20,000 students. It has only been over the last decade that student growth has markedly increased as seen in Table 1.

Table 1 Student Fall Semester Enrollment Numbers (Data provided by FAU office of Student Effectiveness and Analysis)

Boca Campus	2004	2005	2006	2007	2008	2009	5 yr. % change
Enrollment	17,800	18,047	18,180	18,277	19,162	20,256	14%

Over the last five years the student population has grown by approximately 2 percent per year with a student population of over 20,000 enrolled students on the Boca Raton campus in the spring semester of 2010. With the increasing growth of the campus and student body, increasing strain to the traffic and parking conditions have occurred. While approximately a net increase of 600 parking spaces was added on the campus from 2006 to 2010, the student enrolled for the same period of time had an increase of 1,364 students. The current ratio of number of students to parking spaces on campus is approximately 2 to 1 and does not include faculty, staff, and visitors.

As congestion has increased on campus different traffic and parking initiatives have been enacted on. In order to deal with the absence of parking in close proximity to the heart of the campus, the university built two parking garages with a capacity of 1,100 vehicle parking spaces in each. The parking issue came to the forefront of university issues at the beginning of the fall semester in 2009. After the beginning of the semester special unprecedented measures were taken to officially allow parking in specified grass areas around campus as a temporary fix to the problem. The university has implemented a shuttle system to encourage the use of remote access parking, and to reduce congestion on the campus from students driving to different locations within campus.

2. PROBLEM STATEMENT

The shuttle stops as currently scheduled are at the following locations (See Figure 1):

1. Parking Lot 5 (In two different locations)
2. Parking Lot 4 (Near Rec. center and Physical Science buildings)
3. University Village Student Apartments
4. Parking Garage 2 (Near Arts and Letter building)
5. Glades Park Towers (Near on campus student housing)
6. Near Student Union (Cafeteria, Campus housing)
7. College of Business/Education

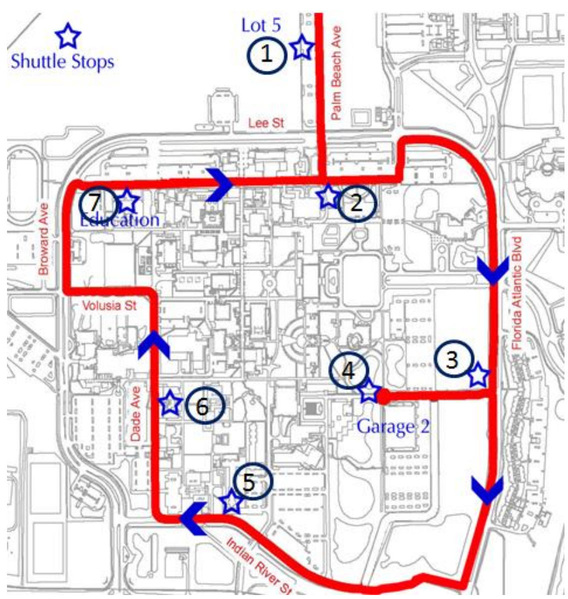

Figure 1 Current FAU Boca Raton shuttle network (Picture provided by FAU parking and Transportation Services)

The FAU shuttle system runs from 7:30 am to 7:30 pm Monday through Friday while classes are in session. Currently FAU is operating 2 shuttles with a 14 passenger capacity (maximum before CDL license is required). Shuttle signs with route map are located at each stop for ease of shuttle stop determination for university pedestrians. Figure 2 and Figure 3 show the signage currently in use at stop locations. Currently the shuttle is free to all pedestrians wishing to use the service without verification of school ID to determine school affiliation.

Figure 2 Signage as currently posted in front of shuttle stops

Figure 3 Students entering the shuttle outside of the Student Union shuttle stop

The intent of this project is to evaluate and make recommendations for the Florida Atlantic University shuttle system. The scope of this study is to review the current shuttle system, and make recommendations on optimizing the shuttle network for the Florida Atlantic University Boca Raton campus for travel time, efficiency, and safety.

3. PROBLEM STATEMENT

Micro simulation was used to analyze existing and future conditions. The simulation platform used was VISSIM version 5.10 using a dual core 3.2 GHz processor with 2.0 GB of ram. The simulation model was created by gathering and collecting data from various sources (such as traffic counts, signal timing, and pedestrian counts) and incorporating them into the simulation model. The simulation road network was developed using both architectural drawings provided by the University Architects office along with aerial photography of the campus per Figure 4 and Figure 5.

The drawing and imagery was loaded into the simulation program to scale as a background image. The road network was then entered following the imported background image. Figure 6 depicts the roadway network as created in the simulation model. The light blue lines indicate vehicle roadway as entered into the simulation model. The yellow trail indicates the shuttle transit line, with red squares indicating shuttle stop location.

Figure 4 AutoCAD drawings of the FAU Boca Raton campus

Figure 5 Aerial photography of the study area

Traffic signal timing was obtained from the City of Boca Raton from a report given by Kimley Horn and Associates. This signal timing was implemented for the intersection of FAU Boulevard and NW 20th Street. Vehicle traffic count data was obtained from Jacobs Engineering for the Boca Raton campus. The vehicle count data included total volumes, and turn movements at different intersections throughout the campus. The vehicle peak hour was determined from the counts to occur between 5:00pm to 6:00pm. The vehicle peak hour traffic count where entered into the simulation model with assumptions made for areas where data did not exist, such as in front of the parking garages.

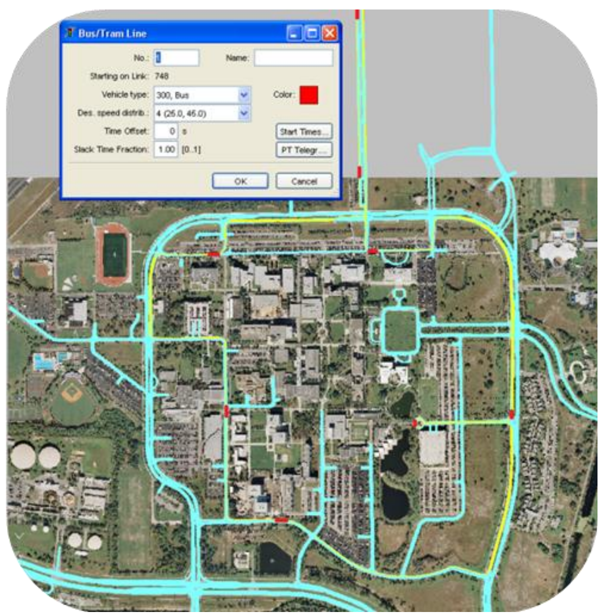

Figure 6 Print-screen image of the road network and shuttle lines in the simulation model

Because college campuses tend to have a high pedestrian movement volume, pedestrian crossing counts were conducted on crosswalks deemed as high flow areas. The objective of conducting the pedestrian counts was to better understand the flow of pedestrians within campus in order to anticipate possible shuttle ridership. Table 2 indicated the locations of where the pedestrian counts were conducted.

Table 2 Pedestrian Crossing Count Locations

Crosswalk	Intersection
1	Dade Av. (In front of Admissions Building.)
2	Dade Av. &Volusia St.
3	Lee St. (In front of LOT 10)
4	Lee St. (In front of LOT 11)
5	Lee St. (In front of LOT 5)
6	Lee St. & St. Lucie Av.
7	20th St. & Florida Atlantic Blvd.
8	Florida Atlantic Blvd. & Student Housing
9	Broward Av. & LOT 15
10	Broward Av. & LOT 16

The pedestrian traffic was incorporated into the simulation as pre-timed traffic signals. The duration and frequency of the pedestrian timing was factored in a method that accounted for the statistical walking speed of pedestrians as determined using the Manual on Uniform Traffic Control Devices for Streets and Highways (TRB 2006). The volume of pedestrians crossing during the peak period, and the assumption of pedestrians traveling in platoons also factored into the simulated wait time of the vehicular traffic. Researchers monitored the shuttle for different 2 hour periods to determine the amount of passengers using the shuttle. The number of passengers directly affects the shuttle route travel time. The observers noted the number of passengers boarding and alighting from the shuttle, and the total dwell time. Dwell times is amount of time that the shuttle is stopped to allow passengers to board and disembark (HCM 2000). The field reported dwell times were not used in the simulation due to atypical values. The reason for the atypical dwell results was the results of riders asking questions to the driver about the shuttle system operations. The model simulates dwell under the assumption that as the shuttle system becomes more used and well known that dwell time will reduce to typical reported values from other agencies. The dwell time used in this simulation uses a 5 second mean time value, with 1 second deviation. Alternative shuttle stop locations were reviewed to determine the best fit shuttle network for both current and future conditions. Figure 7 indicates the location of alternative stop where considered from a preliminary study by the research team. Numbers indicate current stop locations, letters indicate alternative locations.

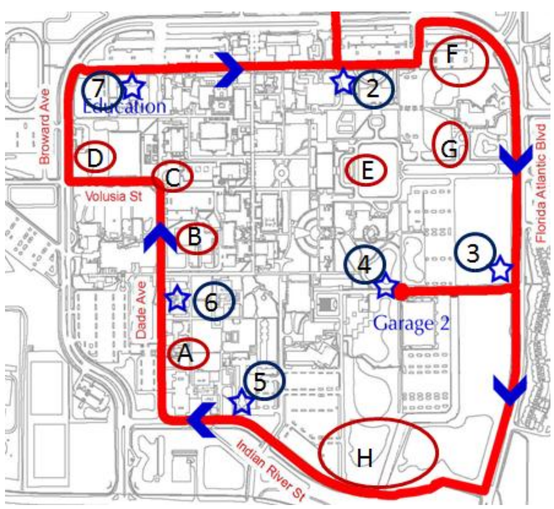

Figure 7 Map of locations where alternative shuttle stops were considered

The alternative shuttle stop locations are at the following locations

A. The pull in bay in front of the Student Support Services building.
B. Mid-block of building 36 (old engineering building).
C. On Volusia, before the parking garage, using paved side area as a shuttle stop bay.
D. On Volusia before Broward Blvd. Includes converting parallel parking spots into a shuttle bay.
E. On the old administration buildings loop. It would share the stop with Palm Tran.
F. Specific location not identified yet. High demand from dual enrolled students with PBSC
G. Loop outside of the new engineering building. Specific site not identified until after construction phase of project is completed and site can be fully evaluated.
H. South parking lot. No specific location identified yet.

In determining the optimal shuttle network many factors were considered such as pedestrian safety, travel time, and ridership. Pedestrian safety was determined by conducting a field study of all current and alternative shuttle stop locations. Pedestrian predicted ridership involved reviewing pedestrian behavior and creating pedestrian Transportation Analysis Zones (TAZ). The transportation zones helped to indicate expected movement behavior within the study area, and relied on the attractiveness of the zone. Primary results of the zone analysis indicated that the College of Business, General Classroom South, Library, Physical Science, and Student Union created the greatest pedestrian demands. The attractiveness of each zone was created by study observations of where pedestrians were going. An informal survey was also conducted by the research assistants to determine destinations that students were heading to on campus. Of special note, significant demand was indicated by the study to include the area by the arena.

4. RESULTS

Calibration and validation of the simulation was first considered and verified. Calibration was determined by comparing reported vehicle counts in the simulation versus field recorded counts by Jacobs Engineering. The results of the calibration in terms of traffic flow indicated a percent difference less than 5%. Network validation was performed by comparing simulated travel times versus actual reported shuttle route travel times. The actual shuttle travel times were determined by using a GPS tracker system that was placed on the bus during 3 separate time periods during peak times during the semester. The GPS data allowed us to review the current shuttle path and travel time between the different segments of the route. Only the times of correctly routed shuttle legs were used in determining the average travel times per segment of the route. The times between segment 7 to 1 and 1 to 2 was recorded even though the routing was consistently performed differently and was not used in validation determination. The shuttle travel times, per segment, during the AM and PM time periods showed low standard deviation and variation range values. The simulation model was run 10 times with different random seeding's. Each simulation was allowed a 15 minute period to ensure the network fully filled before recording traffic results. Each simulation run included two 1-hour period results. The simulation resolution was set to 1 time step per simulation second. The results of the 10 simulated results were then averaged and compared to the travel time recordings by the GPS unit on the shuttles. Table 3, Table 4 and Table 5 show the results of the validation comparison.

Table 3 Simulation versus GPS recorded data (AM)

Sim 10 Runs (sec)		**3/2/10 AM (sec)**	**Range (sec)**	**% Difference**
Time: Stop 1 - 2	191	116	75	64.6
Time: Stop 2 - 3	121.1	138	16.9	12.2
Time: Stop 3 - 4	56.9	50	6.9	13.7
Time: Stop 4 - 5	163.3	163	0.3	0.2
Time: Stop 5 - 6	58.2	55	3.2	5.8
Time: Stop 6 - 7	131.5	138	6.5	4.7
Time: Stop 7 - 1	110.5	170	59.5	35
Avg Travel Time	**832.5**	**830**		7.3

Table 4 Simulation versus GPS recorded data (PM)

Sim 10 Runs (sec)		**3/2/10 PM (sec)**	**Range (sec)**	**% Difference**
Time: Stop 1 - 2	191	107	84	78.5
Time: Stop 2 - 3	121.1	138	16.9	12.2
Time: Stop 3 - 4	56.9	54	2.9	5.3
Time: Stop 4 - 5	163.3	166	2.7	1.6
Time: Stop 5 - 6	58.2	57	1.2	2.1
Time: Stop 6 - 7	131.5	154	22.5	14.6
Time: Stop 7 - 1	110.5	166	55.5	33.4
Avg Travel Time	**832.5**	**842**		**7.2**

Table 5 Simulation versus GPS recorded data (AM)

Sim 10 Runs (sec)		**4/5/10 AM (sec)**	**Range (sec)**	**% Difference**
Time: Stop 1 - 2	191	104	86.99	83.6
Time: Stop 2 - 3	121.1	140	18.9	13.5
Time: Stop 3 - 4	56.9	54	2.86	5.3
Time: Stop 4 - 5	163.3	176	12.66	7.2
Time: Stop 5 - 6	58.2	56	2.19	3.9
Time: Stop 6 - 7	131.5	140	8.49	6.1
Time: Stop 7 - 1	110.5	142	31.5	22.2
Avg Travel Time	**832.5**	**812**		7.2

5. CONCLUSIONS

The simulation results show the simulation to have an average difference from the reported GPS run of 7.2% which is slightly higher than the typical acceptable value of 5% or less. Given more time, a higher level of convergence between the simulation model and field conditions could be achieved. Additional GPS runs with the correct path would help to create a more acceptable average to compare against the simulation and allow greater probability and statistical analysis between the models. As evidenced by the low standard deviation of travel times between the legs of the shuttle, a route schedule approach would be applicable. Because of the continual changing nature of the university campus, modification to both the simulation and route timing will be required to maintain valid time scheduling results.

Four preliminary variations of the current shuttle route were simulated for comparison of travel time. Alternative simulation models for future time periods will be created and discussed at the completion of the second phase of this project at the end of the fall 2011.

The schedule was created by taking the segment times and rounding the values to the nearest minute interval. The segment lengths tended to be close to even minute increments making the rounding of the travel time a convenient step. A schedule was created for the first shuttle bus using the rounded times. The schedule of the second shuttle was created with an adjusted start time and location to create a flow pattern that produces a continual 5 minute frequency of shuttle arrival times. The schedule is based on the current bus shuttle route and stops. The schedule does not include adjustments for driver breaks, driver swapping as currently happens at the parking and transportation facilities building, or abnormal traffic conditions such as events. The times used in the schedule are taken as averages between various traffic scenarios based on peak time traffic conditions and therefore slight variations may occur to expected arrival times.

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Authorization and Disclaimer

6. APPENDIX

Example Schedule

Stop	Shuttle # 1	Shuttle #2	Time Diff
4	7:31 AM	7:36 AM	0:05
5	7:34 AM	7:39 AM	0:05
6	7:35 AM	7:40 AM	0:05
7	7:37 AM	7:42 AM	0:05
1	7:39 AM	7:44 AM	0:05
2	7:42 AM	7:47 AM	0:05
3	7:44 AM	7:49 AM	0:05
4	7:45 AM	7:50 AM	0:05
5	7:48 AM	7:53 AM	0:05
6	7:49 AM	7:54 AM	0:05
7	7:51 AM	7:56 AM	0:05
1	7:53 AM	7:58 AM	0:05
2	7:56 AM	8:01 AM	0:05
3	7:58 AM	8:03 AM	0:05
4	7:59 AM	8:04 AM	0:05
5	8:02 AM	8:07 AM	0:05
6	8:03 AM	8:08 AM	0:05
7	8:05 AM	8:10 AM	0:05
1	8:07 AM	8:12 AM	0:05
2	8:10 AM	8:15 AM	0:05
3	8:12 AM	8:17 AM	0:05
4	8:13 AM	8:18 AM	0:05
5	8:16 AM	8:21 AM	0:05
6	8:17 AM	8:22 AM	0:05
7	8:19 AM	8:24 AM	0:05
1	8:21 AM	8:26 AM	0:05
2	8:24 AM	8:29 AM	0:05
3	8:26 AM	8:31 AM	0:05
4	8:27 AM	8:32 AM	0:05
5	8:30 AM	8:35 AM	0:05
6	8:31 AM	8:36 AM	0:05
7	8:33 AM	8:38 AM	0:05
1	8:35 AM	8:40 AM	0:05
2	8:38 AM	8:43 AM	0:05
3	8:40 AM	8:45 AM	0:05
4	8:41 AM	8:46 AM	0:05
5	8:44 AM	8:49 AM	0:05
6	8:45 AM	8:50 AM	0:05
7	8:47 AM	8:52 AM	0:05

Stop	Shuttle # 1	Shuttle #2	Time Diff
1	8:49 AM	8:54 AM	0:05
2	8:52 AM	8:57 AM	0:05
3	8:54 AM	8:59 AM	0:05
4	8:55 AM	9:00 AM	0:05
5	8:58 AM	9:03 AM	0:05
6	8:59 AM	9:04 AM	0:05
7	9:01 AM	9:06 AM	0:05
1	9:03 AM	9:08 AM	0:05
2	9:06 AM	9:11 AM	0:05
3	9:08 AM	9:13 AM	0:05
4	9:09 AM	9:14 AM	0:05
5	9:12 AM	9:17 AM	0:05
6	9:13 AM	9:18 AM	0:05
7	9:15 AM	9:20 AM	0:05
1	9:17 AM	9:22 AM	0:05
2	9:20 AM	9:25 AM	0:05
3	9:22 AM	9:27 AM	0:05
4	9:23 AM	9:28 AM	0:05
5	9:26 AM	9:31 AM	0:05
6	9:27 AM	9:32 AM	0:05
7	9:29 AM	9:34 AM	0:05
1	9:31 AM	9:36 AM	0:05
2	9:34 AM	9:39 AM	0:05
3	9:36 AM	9:41 AM	0:05
4	9:37 AM	9:42 AM	0:05
5	9:40 AM	9:45 AM	0:05
6	9:41 AM	9:46 AM	0:05
7	9:43 AM	9:48 AM	0:05
1	9:45 AM	9:50 AM	0:05
2	9:48 AM	9:53 AM	0:05
3	9:50 AM	9:55 AM	0:05
4	9:51 AM	9:56 AM	0:05
5	9:54 AM	9:59 AM	0:05
6	9:55 AM	10:00 AM	0:05
7	9:57 AM	10:02 AM	0:05
1	9:59 AM	10:04 AM	0:05
2	10:02 AM	10:07 AM	0:05
3	10:04 AM	10:09 AM	0:05
4	10:05 AM	10:10 AM	0:05
5	10:08 AM	10:13 AM	0:05
6	10:09 AM	10:14 AM	0:05
7	10:11 AM	10:16 AM	0:05

Stop	Shuttle # 1	Shuttle #2	Time Diff	Stop	Shuttle # 1	Shuttle #2	Time Diff
1	10:13 AM	10:18 AM	0:05	1	11:37 AM	11:42 AM	0:05
2	10:16 AM	10:21 AM	0:05	2	11:40 AM	11:45 AM	0:05
3	10:18 AM	10:23 AM	0:05	3	11:42 AM	11:47 AM	0:05
4	10:19 AM	10:24 AM	0:05	4	11:43 AM	11:48 AM	0:05
5	10:22 AM	10:27 AM	0:05	5	11:46 AM	11:51 AM	0:05
6	10:23 AM	10:28 AM	0:05	6	11:47 AM	11:52 AM	0:05
7	10:25 AM	10:30 AM	0:05	7	11:49 AM	11:54 AM	0:05
1	10:27 AM	10:32 AM	0:05	1	11:51 AM	11:56 AM	0:05
2	10:30 AM	10:35 AM	0:05	2	11:54 AM	11:59 AM	0:05
3	10:32 AM	10:37 AM	0:05	3	11:56 AM	12:01 PM	0:05
4	10:33 AM	10:38 AM	0:05	4	11:57 AM	12:02 PM	0:05
5	10:36 AM	10:41 AM	0:05	5	12:00 PM	12:05 PM	0:05
6	10:37 AM	10:42 AM	0:05	6	12:01 PM	12:06 PM	0:05
7	10:39 AM	10:44 AM	0:05	7	12:03 PM	12:08 PM	0:05
1	10:41 AM	10:46 AM	0:05	1	12:05 PM	12:10 PM	0:05
2	10:44 AM	10:49 AM	0:05	2	12:08 PM	12:13 PM	0:05
3	10:46 AM	10:51 AM	0:05	3	12:10 PM	12:15 PM	0:05
4	10:47 AM	10:52 AM	0:05	4	12:11 PM	12:16 PM	0:05
5	10:50 AM	10:55 AM	0:05	5	12:14 PM	12:19 PM	0:05
6	10:51 AM	10:56 AM	0:05	6	12:15 PM	12:20 PM	0:05
7	10:53 AM	10:58 AM	0:05	7	12:17 PM	12:22 PM	0:05
1	10:55 AM	11:00 AM	0:05	1	12:19 PM	12:24 PM	0:05
2	10:58 AM	11:03 AM	0:05	2	12:22 PM	12:27 PM	0:05
3	11:00 AM	11:05 AM	0:05	3	12:24 PM	12:29 PM	0:05
4	11:01 AM	11:06 AM	0:05	4	12:25 PM	12:30 PM	0:05
5	11:04 AM	11:09 AM	0:05	5	12:28 PM	12:33 PM	0:05
6	11:05 AM	11:10 AM	0:05	6	12:29 PM	12:34 PM	0:05
7	11:07 AM	11:12 AM	0:05	7	12:31 PM	12:36 PM	0:05
1	11:09 AM	11:14 AM	0:05	1	12:33 PM	12:38 PM	0:05
2	11:12 AM	11:17 AM	0:05	2	12:36 PM	12:41 PM	0:05
3	11:14 AM	11:19 AM	0:05	3	12:38 PM	12:43 PM	0:05
4	11:15 AM	11:20 AM	0:05	4	12:39 PM	12:44 PM	0:05
5	11:18 AM	11:23 AM	0:05	5	12:42 PM	12:47 PM	0:05
6	11:19 AM	11:24 AM	0:05	6	12:43 PM	12:48 PM	0:05
7	11:21 AM	11:26 AM	0:05	7	12:45 PM	12:50 PM	0:05
1	11:23 AM	11:28 AM	0:05	1	12:47 PM	12:52 PM	0:05
2	11:26 AM	11:31 AM	0:05	2	12:50 PM	12:55 PM	0:05
3	11:28 AM	11:33 AM	0:05	3	12:52 PM	12:57 PM	0:05
4	11:29 AM	11:34 AM	0:05	4	12:53 PM	12:58 PM	0:05
5	11:32 AM	11:37 AM	0:05	5	12:56 PM	1:01 PM	0:05
6	11:33 AM	11:38 AM	0:05	6	12:57 PM	1:02 PM	0:05
7	11:35 AM	11:40 AM	0:05	7	12:59 PM	1:04 PM	0:05