

## An Implementation of Transparent Employee Monitoring System by Jump Lists of Windows

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**ABSTRACT :** Maximizing the positive effects and minimizing the negative effects of employee monitoring system (EMS) are the important issues in the business environment. This paper aims to develop a new transparent EMS for the users of Windows 10 to mitigate the negative effects of EMS including invading employees' reasonable expectation of privacy, increasing employees' working stress and distrust, etc. The transparent EMS, named JumpListM, is the first one which applies the records of Jump Lists to monitor the applications run in employees' computers. The system depends on the Jump Lists, which are the new functions of Windows systems to allow users to quickly access the recent directories, files, and operations that have been used as well as to collect those records as per application basis. Due to the Jump Lists containing a lot of records, the records will be rendered to be the monitoring features in this paper. The JumpListM monitor is implemented as a GUI tool by Python 3.5. It can record what kinds of applications are run at a specific time in a computer. According to the information, a user's behavior running applications in computer can be monitored. To compare the proposed JumpListM monitor system with the other newest EMSs in the Internet, JumpListM gets maximum advantages.

**KEYWORDS** -Transparent Employee monitoring system (EMS); Jump Lists; Windows 10; Employees' Privacy; JumpListM;

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### I. INTRODUCTION

Jump Lists have been introduced as a new function since Windows 7 was released and have been applied as forensic features. The main purpose of Jump Lists is to allow users to quickly access applications, files, and operations that have been used, therefore, it is also called "jump to a list". It is similar to the shortcut method which can take a user to move to the user's frequently used files or directories directly. However, unlike the normal shortcut shortcuts, Jump Lists are extended to contain more information [1]. Although in Windows 7/8 operating system, there are many Jump Lists analysis tools [2]-[7], but in Windows 10, the above tools cannot work properly since that the structure of Jump Lists of Windows 10 has been updated. The Jump Lists structure of Windows 10 version have exposed much more functionality and information [4][8][9]. Therefore, it is a challenge to design a parsing tool of Windows 10 Jump Lists. Jump Lists are very helpful in establishing the schedule of events in a computer with Windows. In the paper, the time records of Jump Lists are extracted to track the events of users. For investigators, they can take advantage of this service and look into the user's computer activities, habits and knowledge.

About the employee monitoring systems, employers can use the systems to monitor their employees' actions in computer in the workplace. Meanwhile, the employees can also get advantages from the monitoring including immediate feedback, monitoring employees' working efficiency and frightening unethical/illegal behavior. Currently, there are several top open source EMSs in the Internet [10][11]. Those software requires installing client agents in the local computer to monitor every detail of their employees' actions, communications and even tracking employees' whereabouts both inside and outside the workplace. However, it is a problem that excessive and unreasonable monitoring employees can invade privacy, increase working stress and make employees feel distrust. Therefore, the authors of the paper [12] also think that employee monitor is dehumanizing and violates personal privacy by breaching personal information. Besides, critics give evidence to show that monitoring may make the organization less effective and the monitored employees perform worse on creative or complex tasks [12]. The paper [13] summarizes 5 bad situations for eavesdropping employees. They are leading employees to sneak around to conduct personal activities on work time, invading an employee's reasonable expectation of privacy, lower morale, causing employees to complain and causing employees to fear using equipment even for benign work purposes. To overcome the drawbacks of employee monitor and for

mitigating the negative effects and maximizing the positive effects of EPM (Employee Performance Management), The paper [14] provides 5 evidence-based recommendations in implementing EPM including being transparent, only monitoring work-related behavior and organizational makeup when using the EPM, etc. Therefore, in the paper, a local computer agent-free (transparent) employee monitoring system with Jump Lists for Windows 10 users is proposed. Since Jump Lists is from Windows system program, it is transparent, that is to say, there is no extra agent tool installed in local computer. It just only requires dispatching the files which contain Jump Lists records to a monitor server in the computer center at a fixed schedule. This way will reduce significantly the employees' concern about the drawbacks of EPM or EMS, for example, invading an employee's reasonable expectation of privacy, increasing employees' working stress and distrust, etc.

In the following section, the structure of Jump Lists are briefly summarized. Section 3 introduces the functions of the proposed monitor system, called JumpListM, in details. The experimental results and the comparisons between the proposed transparent employee monitor system and the other EMSs are described in the Section 4, followed by conclusion in Section 5.

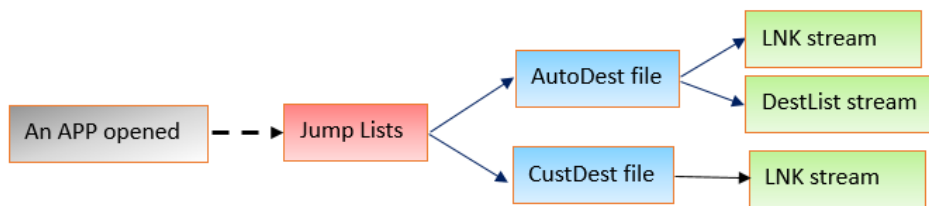


Fig. 1 The file flow of Jump Lists

## II. STRUCTURE OF JUMP LISTS

The records of Jump Lists are contained in two types of hidden files. They are AutoDest and CustDest. The AutoDest (\*.automaticDestinations-ms) files are generated by Windows operating system shell and are stored in C:\Users\[UserProfile]\AppData\Roaming\Microsoft\Windows\Recent\AutomaticDestinations.

The CustDest (\*.customDestinations-ms) files are created by special applications to store specific records for the applications. The following folder stores these files. C:\Users\[UserProfile]\AppData\Roaming\Microsoft\Windows\Recent\CustomDestinations.

The file format of AutoDest files is Microsoft Compound File Binary (CFB), also known as OLE (Object Linking and Embedding) file. The AutoDest files contain MS-SHLLINK streams and DestList streams. The structure of MS-SHLLINK is similar to that of Windows Shortcut (LNK) file. The DestList stream acts as a most recently/frequently used (MRU/MFU) list. The DestList stream consists of DestList header and DestList Entry [8]. The file flow of the Jump Lists are illustrated in Fig. 1. That is to say, the Jump Lists are created while an application is being opened. Several important records of Jump Lists extracted out by parser are listed in Fig. 2.

About the CustDest files, storing custom Jump Lists only, these files are specified by the application using ICustomDestinationList API [15]. These custom Jump Lists store the contents that the application has considered significant lists through an action, such as a user is pinning files and folders to the desktop (or the taskbar) or adding an item to a favorite list.

## III. THE FUNCTIONS OF THE PROPOSED MONITOR SYSTEM

The system structure of the proposed JumpListM is illustrated in Fig. 3. The proposed system is also called JumpListM. Owing to many data recorded in Jump Lists, in JumpListM monitor system, firstly, the Jump Lists files are parsed. Then, the monitoring function extracts the specific records to analyze. Fig.4 demonstrates the snapshot of the parsing results. In the records of Fig. 4, for the monitoring purpose, the most useful ones are the five kinds of timestamps which are applied in JumpListM to monitor individual application. They are Created time, Birth time, Accessed time, Modified time and Last Recorded Access time. Those timestamps are listed as Created, Birth, Accessed, Modified and Last Recorded Access in the first row of Fig. 4, respectively. The meanings of the five kinds of timestamps are defined as follows [16][17].

- (1). Created time: This time specifies the first time a file or folder created or it is copied to a location.
- (2). Accessed time: If a file is opened or edited or moved or copied, this time will be changed.
- (3). Modified time: If a file is edited, this time will get updated.
- (4). Birth time: This is the time when a file is created. It will not be changed afterward. The difference between created time and birth time is that the created time will be updated after a file is copied to a location.
- (5). Last Recorded Access time: This time gets changed if the created time or accessed time or modified time are updated. That is to say, this timestamp follows any one of MSFILETIME to be updated.

The first four kinds of timestamps are from the AutoDest LNK stream of Jump Lists and the fifth one is stored in the AutoDestDestList stream. In Table 1, the actions corresponding to the changes of the different timestamps are summarized. The Last Recorded Access time is related to all of the actions and its record is protected by CRC-64 in the DestList stream that is separated from the LNK stream. Please notice that no open and open represent the files not be opened and be opened, respectively. Therefore, in our JumpListM system, the Last Recorded Access time is adopted as the feature to track the actions of applications run in Windows 10 since it is the most sensitive and reliable timestamp.

The purpose of the JumpListM is to monitor what kinds of applications run at a time point by an employee. The administrator can setup the application whitelist and blacklist as the applications allowed and the applications not allowed to be used in the work hours, respectively.

In the scenario of an organization, the JumpList records can be sent to a server in the datacenter by a regular schedule, and then apply JumpListM to analyze the JumpLists of every employee. For the cloud application, JumpListM can be run in the new version Microsoft Server to monitor the employees who are running applications in virtual machine.

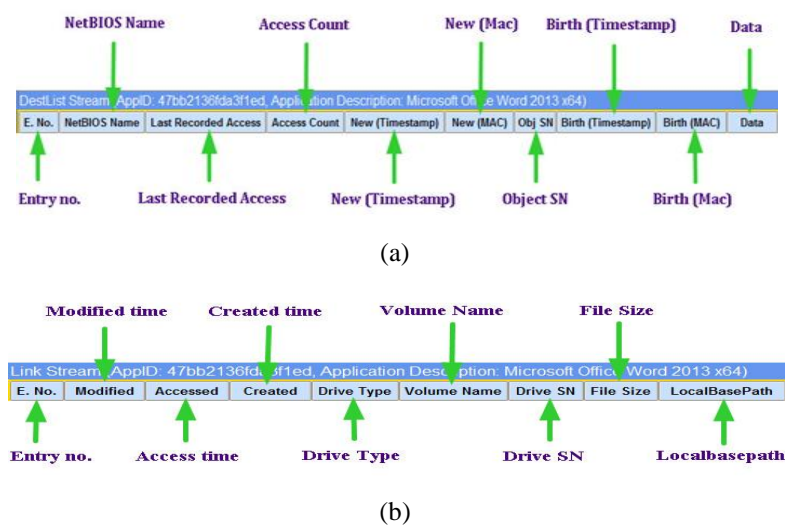


Fig. 2 (a) The Jump Lists records parsing from AutoDest LNK stream. (b) The Jump Lists records parsing from AutoDestDestList stream

#### IV. EXPERIMENT

JumpListM system is designed by Python 3.5 with the IDE of Wing Personal 6.0. The parsing result of JumpLists is demonstrated in Fig. 4. The columns are the records of JumpLists and every row represents an application which was run by a user or was evoked by Windows operating system shell.

Table 2 shows an example that JumpListM monitors a user who was running applications in time sequence during a work day. The scenario is that the work hours are from 8 to 18 and there is a whitelist which lists the applications allowed to be used in the work hours. If an application not listed in whitelist is run in the work hours by a user, it will get a bold dark alarm circle to highlight. For example, in Table 2, Wireshark 2.4.2 get an alarm since it was not in whitelist and was run in the working hours (16:25) in a day. As for Cisco packet tracker and Wing personal 6.0 in Table 2, they were not in whitelist but they were run at the outside of the work hours. Thus, they didn't get alarm signs. It means that they were legal at that situation. In Table 2, the time records of applications are from the Last Recorded Access timestamp. Owing to the Last Recorded Access timestamp is related to MSFILETIME (Created time or Accessed time or Modified time) and the Last Recorded Access timestamp is the most sensitive and reliable one, JumpListM tracks an application run by a user according to the Last Recorded Access timestamp. In addition, Windows Explorer 8.1 and Quick Access are the two most frequent applications. The reasons are that usually a user searches files by Windows Explorer (File Explorer) or launches an application or a file as quickly as possible from Quick Access often. The monitoring result of JumpListM for a user is illustrated in Fig. 5. The application names are listed in left side of Fig. 5. The blue ones represent the applications which are in the whitelists. In the contrary, and the red ones are not in the whitelists.

Table 3 is the comparisons between the proposed JuntListM and several newest employee monitoring systems. The free share systems from the Internet are TeraMind[18], ActivTrak[19], Veriato 360 [20], SonigaSwiftTime[21], CKZ Time Clock [22], iSafe Free Keylogger[23], Screenshot Monitor [24] and

ClockIt[25]. The systems which are not free are excluded. But, most of free systems limit the monitoring employee's number or available days. For cloud-based application, ActivTrak, TeraMind, VeriClock[26], SonigaSwiftTime, CKZ Time Clock, Screenshot Monito, ClockIt and JumpListM provide the cloud functions. However, several systems are the cloud employee attendance management system only. For example, ActivTrak, SonigaSwiftTime and ClockIt have no functions in monitoring the running applications of the employees' computers. JumpListM can be run in Windows 10 Jump Lists compatible Microsoft Windows Server which are running the cloud functions. In comparison of user friendly interface, the interface complexities of Qustodio [27] Time doctor [28], FoneMonitor [29], iSafe Free Keylogger, Screenshot Monito and JumpListM are lower than the others. As for the visualization design, ActivTrak, InterGuard[30], Veriato 360, SonigaSwiftTime, CKZ Time Clock and JumpListM use the GUI interface and display the results by visualized charts.

Finally, the most important one is related to the invading privacy problem of employee monitoring systems. All of the above employee monitoring systems invade employees' privacy severely. Even some of the employee monitoring systems track employees' whereabouts by GPS. JumpListM is transparent and doesn't require client agent installed in client computer and it uses Jump Lists records produced by Windows 10 system programs to seamlessly monitor the applications the employees have run. This way will have no invading an employee's reasonable expectation of privacy and reduce the employees' working stress and distrust significantly. In addition, the other advantage is that Jump Lists records are protected by CRC-64 error correction code. The records are not easy to be tampered.

### V. CONCLUSION

To apply the Jump Lists information in EMS is a new idea which is implemented in the system JumpListM. In JumpListM monitoring system, the Jump Lists records are parsed and analyzed to get information as the monitor features. Jump Lists records are produced by Windows operating system shell and there are no extra client agents needed to be installed inside the employees' computers. Therefore, it is a transparent EMS. To compare JumpListM with the other newest employee monitoring systems in the Internet, JumpListM not only get less employees' privacy invading but also accurately track the applications which have been run. Therefore, the monitoring way of JumpListM will be accepted by employees more easily. In addition, it can also be run in a cloud-based system.

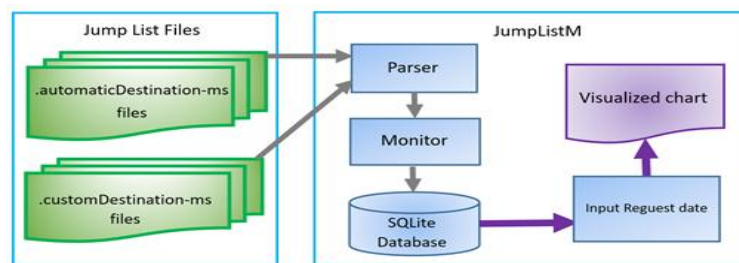


Fig. 3 The system structure of the proposed JumpListM

Appid	Appname	E: I: N:	Last Recorded Access	Modified	Accessed	Created	Ac Di Vc:	Birth(Timestamp)	Bl: Se
5f7b5f1e01b83767	Quick Access	21	2019-06-18 08:03:49	2018-07-30 07:07:51	2018-07-30 07:07:51	2018-07-30 07:07:51	3 Fi	None	00 0 C:\pythonwork\107nana
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-18 08:03:48	2019-06-15 10:07:09	2019-06-15 10:07:09	2018-02-11 09:51:58	2 Fi	2018-02-11 08:26:14	54 4E C:\pythonwork\107nana
1c748ecc3e2a2a6e	NA	47 ne	2019-06-18 08:03:48	2018-07-30 07:07:51	2018-07-30 07:07:51	2018-07-30 07:07:51	3 Fi	2019-06-15 08:58:17	54 4E C:\pythonwork\107nana
f01b4d95cf55d32a	Windows Explorer Windows 8.1	1C ne	2019-06-18 08:02:02	2019-06-18 08:02:02	2019-06-18 08:02:02	2018-10-10 21:22:07	11 Fi	2018-10-10 20:00:04	54 4E C:\nana真正念\Chung Ta
5f7b5f1e01b83767	Quick Access	22	2019-06-18 08:02:02	2018-10-10 21:18:43	2018-10-10 21:18:43	2018-10-10 21:15:30	6 Fi	None	00 0 C:\nana真正念\Chung Ta
47bb2136fda3f1ed	Microsoft Office Word 2013 x64	45 ne	2019-06-18 08:02:02	2018-10-10 21:18:43	2018-10-10 21:18:43	2018-10-10 21:15:30	6 Fi	2018-10-10 20:00:04	54 4E C:\nana真正念\Chung Ta
a52b0784bd667468	Photos Microsoft 16\Windows 10	25 ne	2019-06-18 07:59:09	2018-10-24 22:12:45	2018-10-24 22:12:45	2018-10-24 22:12:45	2 Fi	2018-10-24 21:45:25	54 4E C:\nana真正念\张军超\张
5f7b5f1e01b83767	Quick Access	23 ne	2019-06-18 07:59:09	2018-10-24 22:12:45	2018-10-24 22:12:45	2018-10-24 22:12:45	2 Fi	2018-10-24 21:45:25	54 4E C:\nana真正念\张军超\张
f01b4d95cf55d32a	Windows Explorer Windows 8.1	4E ne	2019-06-18 07:59:03	2019-06-18 07:59:03	2019-06-18 07:59:03	2017-10-15 15:11:40	8C Fi	2017-10-15 14:56:14	54 4E C:\nana真正念
f01b4d95cf55d32a	Windows Explorer Windows 8.1	2C ne	2019-06-18 07:58:41	2019-06-18 07:58:41	2019-06-18 07:58:41	2016-05-01 09:51:57	21 Fi	2016-07-29 07:05:48	54 4E knowfolder\754AC886-
47bb2136fda3f1ed	Microsoft Office Word 2013 x64	15 ne	2019-06-18 07:58:41	2017-05-14 15:08:15	2017-05-14 15:08:14	2017-05-14 15:08:14	23 Fi	2017-05-14 14:57:39	00 4E C:\Users\NANA\Desktop
f01b4d95cf55d32a	Windows Explorer Windows 8.1	56 ne	2019-06-18 07:56:22	2019-06-18 07:54:15	2019-06-18 07:54:15	2017-07-24 19:18:19	3 Fi	2017-07-24 18:57:12	00 4E C:\106Linda_test
09bacc0999d4104	Microsoft Office Excel 2013 x64	1E ne	2019-06-18 07:53:56	2017-02-04 23:17:54	2017-02-04 23:17:54	2017-02-04 23:17:54	1 Fi	2017-02-04 14:16:34	54 4E C:\106Linda_test\大李望
5f7b5f1e01b83767	Quick Access	3E	2019-06-18 07:53:56	2017-02-04 23:17:54	2017-02-04 23:17:54	2017-02-04 23:17:54	2 Fi	None	00 0 C:\106Linda_test\大李望
5f7b5f1e01b83767	Quick Access	22 ne	2019-06-15 10:36:09	2018-10-14 00:40:05	2018-10-14 00:59:44	2018-10-14 00:59:44	12 Fi	2018-10-14 00:11:17	54 4E C:\nana研究所-NDU\10
f01b4d95cf55d32a	Windows Explorer Windows 8.1	1C ne	2019-06-15 10:36:08	2019-06-15 10:36:08	2019-06-15 10:36:08	2018-09-27 07:24:40	72 Fi	2018-09-27 07:16:34	54 4E C:\nana研究所-NDU\10
47bb2136fda3f1ed	Microsoft Office Word 2013 x64	5C ne	2019-06-15 10:36:08	2018-10-14 00:40:05	2018-10-14 00:59:44	2018-10-14 00:59:44	1C Fi	2018-10-14 00:11:17	54 4E C:\nana研究所-NDU\10
5f7b5f1e01b83767	Quick Access	22 ne	2019-06-15 10:04:54	2018-09-28 08:15:19	2018-09-28 08:15:19	2018-09-27 07:26:32	23 Fi	2018-09-28 01:49:33	00 4E C:\nana研究所-NDU\10
47bb2136fda3f1ed	Microsoft Office Word 2013 x64	4E ne	2019-06-15 10:04:53	2018-09-28 08:15:19	2018-09-28 08:15:19	2018-09-27 07:26:32	23 Fi	2018-09-28 01:49:33	00 4E C:\nana研究所-NDU\10
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-15 09:13:51	2018-05-06 15:10:49	2018-05-06 15:10:49	2018-04-18 21:34:14	1 Fi	2018-04-18 19:07:14	54 4E C:\nana\AB01
e4e82c3b81abb9f6	Adobe Reader X 10.1.0	3E ne	2019-06-15 09:13:51	2018-05-06 15:10:49	2018-05-06 15:10:49	2018-05-06 15:10:49	1 Fi	2018-05-06 08:21:20	54 4E C:\nana\AB01\test-A fore
5f7b5f1e01b83767	Quick Access	1E ne	2019-06-15 09:13:51	2018-05-06 15:10:49	2018-05-06 15:10:49	2018-05-06 15:10:49	2 Fi	2018-05-06 08:21:20	54 4E C:\nana\AB01\test-A fore
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-11 07:17:45	2019-06-11 07:17:40	2019-06-11 07:17:40	2019-06-11 07:16:26	1 Fi	2019-06-11 06:28:48	54 4E C:\nana_data\1080627
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-11 07:17:45	2019-06-11 07:16:26	2019-06-11 07:16:31	2019-06-11 06:57:02	4 Fi	2019-06-11 06:28:48	54 4E C:\nana_data\1080627
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-11 07:16:13	2019-06-11 07:16:13	2019-06-11 07:16:13	2019-06-11 07:16:12	1 Fi	2019-06-11 06:28:48	54 4E C:\nana_data\1080627
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-11 07:16:13	2019-06-11 07:16:12	2019-06-11 07:16:12	2019-06-11 07:16:01	1 Fi	2019-06-11 06:28:48	54 4E C:\nana_data\1080627
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-11 07:16:13	2019-06-11 07:16:01	2019-06-11 07:16:01	2019-06-11 07:16:01	1 Fi	2019-06-11 06:28:48	54 4E C:\nana_data\1080627
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-11 07:16:13	2019-06-11 07:15:59	2019-06-11 07:15:59	2019-06-11 07:15:55	1 Fi	2019-06-11 06:28:48	54 4E C:\nana_data\1080627
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-11 07:16:13	2019-06-11 07:15:55	2019-06-11 07:15:55	2019-06-11 07:15:53	1 Fi	2019-06-11 06:28:48	54 4E C:\nana_data\1080627
f01b4d95cf55d32a	Windows Explorer Windows 8.1	11 ne	2019-06-11 07:16:13	2019-06-11 07:15:53	2019-06-11 07:15:53	2019-06-11 07:15:53	1 Fi	2019-06-11 06:28:48	54 4E C:\nana_data\1080627

Fig. 4 The snapshot of the parsing results by JumpList

**Table 1** The relations of actions and timestamps

Time \ Actions	Last Recorded Access time	Created time	Accessed time	Modified Time	Birth
Create	*	*	*	*	*
Open	*		*		
Edit	*		*	*	
Save	*		*	*	
Close	*		*		
Copy (No open)	*	*			
Copy (Open)	*	*	*	*	*
Move (No open)	*		*	*	
Move (Open)	*	*	*	*	*
Rename (Open)	*		*		

**Table 2** Applications run in time sequence

Time	AppID	Appname	8-18	Not in whitelists	Alarm
7:56	47bb2136fda3f1ed	MS Office Word 2013(64)			
7:56	5f7b5f1e01b83767	Quick Access			
7:58	4cc9bcff1a772a63	MS office PowerPoint 2013(64)			
7:58	5f7b5f1e01b83767	Quick Access			
7:59	f01b4d95cf55d32a	Windows Explorer 8.1			
8:00	ee462c3b81abb6f6	Adobe Reader X 10.1.0			
8:00	5f7b5f1e01b83767	Quick Access			
8:18	74d7f43c1561fc1e	Media Player12(32)	⊙		
8:18	5f7b5f1e01b83767	Quick Access			
13:14	9b9cdc69c1c24e2b	Notepad (64-bit)	⊙		
13:14	5f7b5f1e01b83767	Quick Access			
16:13	47bb2136fda3f1ed	MS Office Word 2013(64)	⊙		
16:13	5f7b5f1e01b83767	Quick Access			
16:25	fe57f5df17b45fe	Wireshark 2.4.2(64)	⊙	⊙	⊙
16:25	5f7b5f1e01b83767	Quick Access			
18:30	dec4ec1476a81341	cisco packet tracer		⊙	
18:30	5f7b5f1e01b83767	Quick Access			
20:39	f01b4d95cf55d32a	Windows Explorer 8.1			
21:29	1c748ecc36e2a6e	Wing Personal 6.0		⊙	
21:29	5f7b5f1e01b83767	Quick Access			
21:29	f01b4d95cf55d32a	Windows Explorer 8.1			
21:34	f01b4d95cf55d32a	Windows Explorer 8.1			

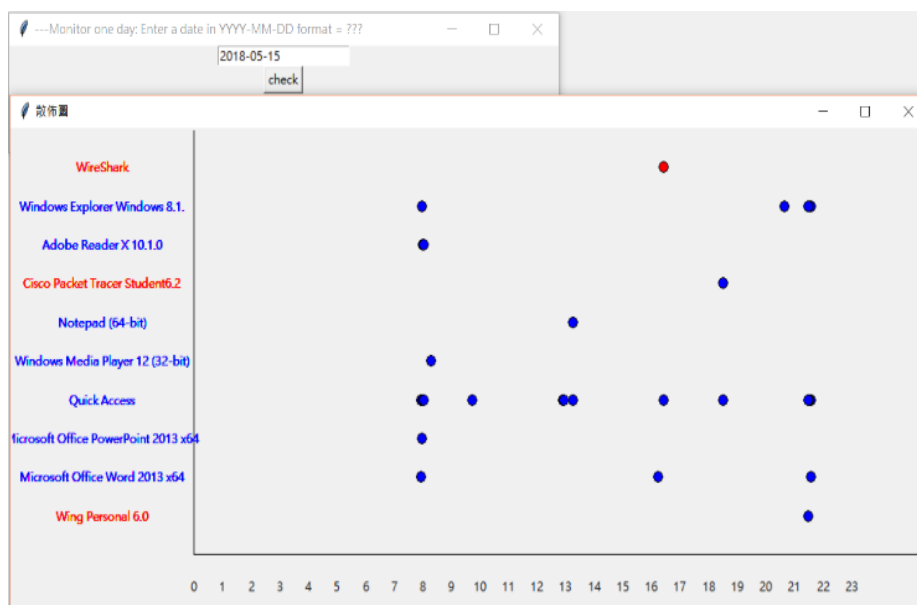


Fig. 5 The monitoring result of JumpListM for a user

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