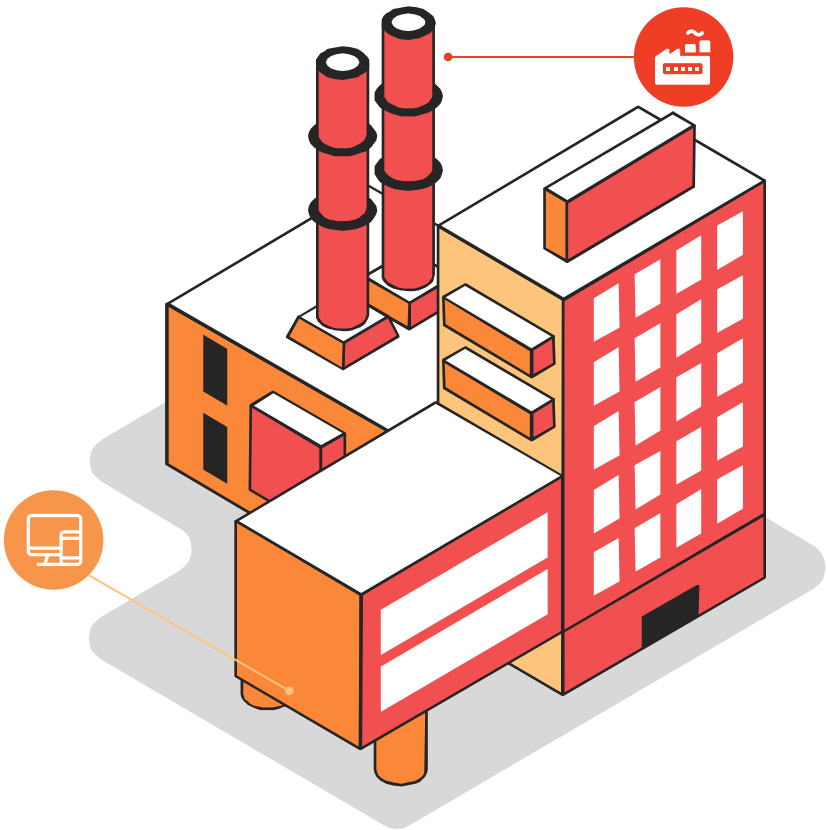
Enterprise Facility Management System

Presented by: **Team Finders**

Heyujia Du, Tong Jiang, Xizhu Lin,

Yingyue (Alycia) Qiu, Jiarui Xia



PROBLEMS & WHY MATTER?

Current Situation & Problems Found

APPROACH

Data Exploration

SOLUTION

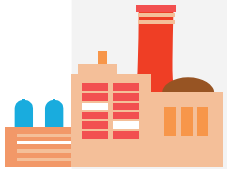
Detailed Steps

FUN FACT

Fun Data Findings that
Worth Mentioning

Q&A

Companies Face Security and Operation Problems



$3.6 Billion

every year

Due to Intellectual Property Theft

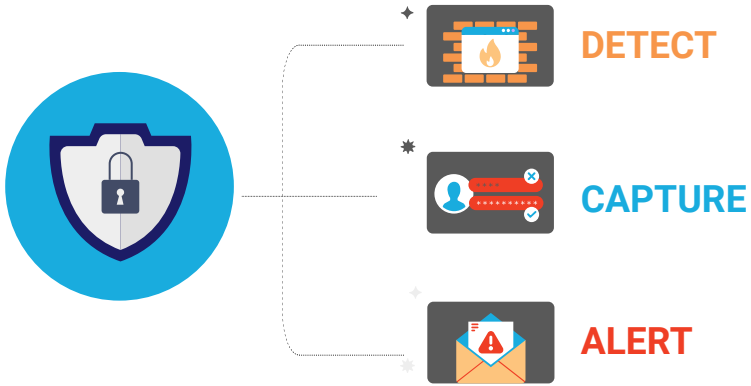
Nearly

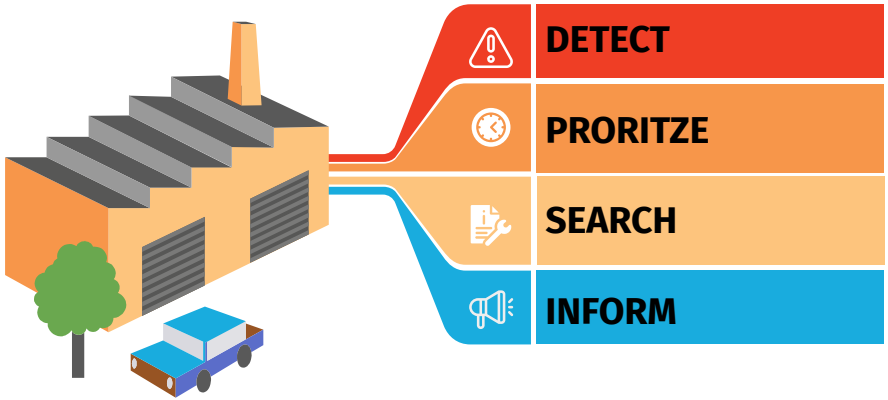
$1.5 Trillion

Per year

Due to Machine Downtime

The Ultimate Solution:
One-Stop Facility Management System





Safe Sphere

Smart Maintenance

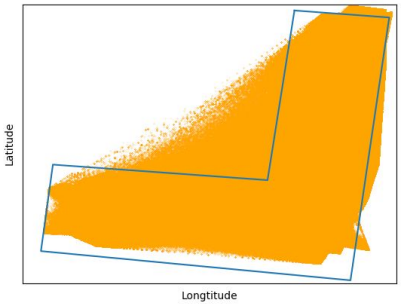
271,543,853 Rows of Data Remained after Data Cleaning

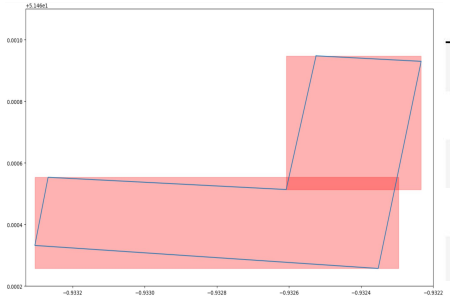
1. Clean missing values and 00:00:00:00 all zero Mac Address

2. Delete observations outside the building

3. Intercept time to the exact second and keep one row per second

4. Remove mac address appears only once





	Site	Level	ClientMacAddr	lat	lng	localtime
0	UK Office	Ground Floor	9c:da:3e:7e:f9:14	51.460572	-0.932384	2019-09-13 15:52:18
1	UK Office	Ground Floor	04:69:f8:78:ce:b2	51.460524	-0.932309	2019-09-13 15:52:18
2	UK Office	Ground Floor	88:66:a5:56:68:6a	51.460632	-0.932401	2019-09-13 15:52:18
3	UK Office	Ground Floor	a4:c3:f0:a5:f0:af	51.460559	-0.932538	2019-09-13 15:52:18
4	UK Office	Ground Floor	9c:da:3e:69:cb:75	51.460649	-0.932366	2019-09-13 15:52:18

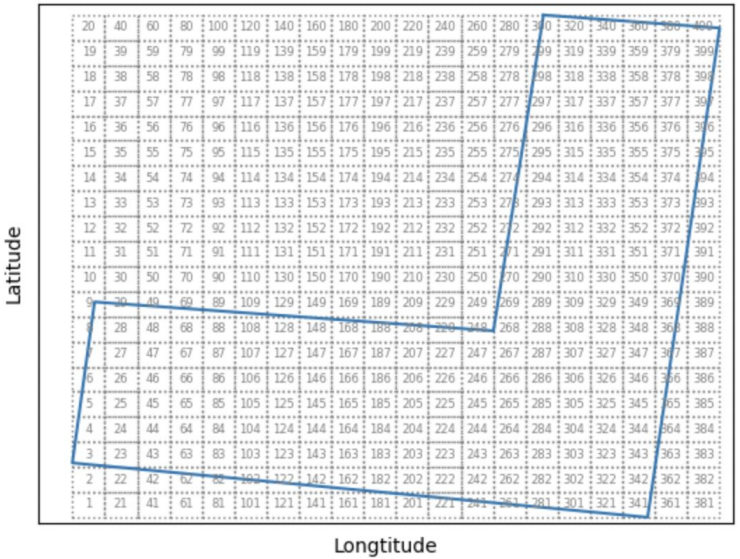
We Divide the Building into k-by-k Grid System

```python
def assign_zones(dataframe, x_min, x_max, y_min, y_max, k):
    # Define the x and y boundaries of the grid
    x_step = (x_max-x_min)/k
    y_step = (y_max-y_min)/k

    # assign zone number for the given dataframe
    zone_num = 1
    for i in range(k):
        for j in range(k):
            x = x_min + i * x_step
            y = y_min + j * y_step
            mask = ((dataframe['lng'] >= x) & (dataframe['lng'] <= x + x_step) &
                    (dataframe['lat'] >= y) & (dataframe['lat'] <= y + y_step))
            dataframe.loc[mask, 'ZoneID'] = zone_num
            zone_num += 1
    dataframe['ZoneID'] = dataframe['ZoneID'].astype(int)
    return dataframe
```

	ClientMacAddr	Site	Level	lat	lng	date	time	timestamp	ZoneID
0	00:08:22:64:35:40	UK Office	Ground Floor	51.460766	-0.932372	2019-08-13	09:29:56	2019-08-13 09:29:56	335
1	00:08:22:64:35:40	UK Office	Ground Floor	51.460733	-0.932415	2019-08-13	09:30:06	2019-08-13 09:30:06	314
2	00:08:22:64:35:40	UK Office	Ground Floor	51.460733	-0.932415	2019-08-13	09:30:16	2019-08-13 09:30:16	314
3	00:08:22:64:35:40	UK Office	Ground Floor	51.460733	-0.932415	2019-08-13	09:30:26	2019-08-13 09:30:26	314
4	00:08:22:64:35:40	UK Office	Ground Floor	51.460733	-0.932415	2019-08-13	09:30:36	2019-08-13 09:30:36	314

x_min = -0.9332446313023279
x_max = -0.9321732468412318
y_min = 51.460257062787136
y_max = 51.46094763183397
k = 20



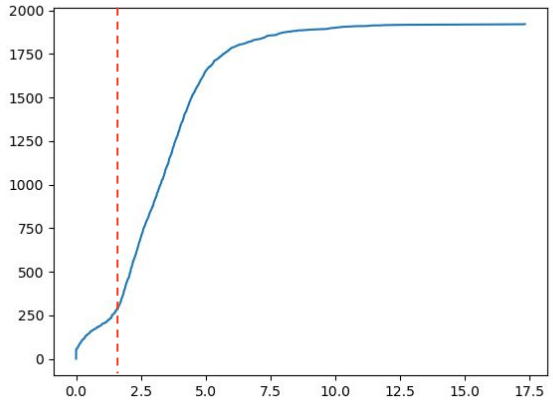
How Do We Find Fixed Devices:
Distance, Speed and Number of Days Impact Device Classification

Manufacturer	Type
Motorola Mobility LLC, a Lenovo Company	Mobile
Apple, Inc.	Mobile

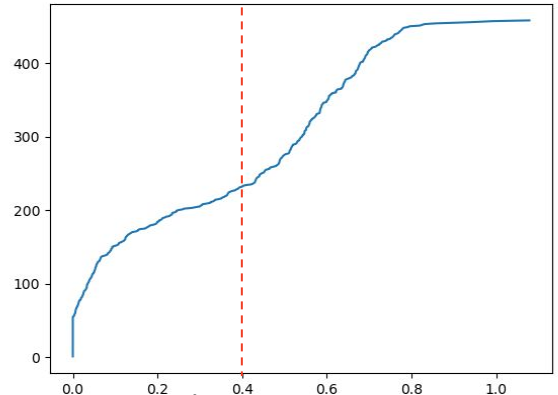
Manufacturer	Type
MediaTek Inc.	Fixed
ALPSALPINE CO,.LTD	Fixed

	ClientMacAddr	distance_mean	distance_median	distance_std	distance_max	speed_mean	speed_median	speed_std	speed_max
0	00:00:11:11:31:10	0.034513	0.000000	0.185861	1.000891	0.003451	0.000000	0.018586	0.100089
1	00:0a:f5:40:18:c0	1.763421	0.000000	5.649001	86.727820	0.203938	0.000000	0.887636	19.997364
2	00:21:6b:fb:e8:cf	1.378755	0.272532	3.644215	78.282313	0.141135	0.027373	0.414997	14.247589

Cumulative Distribution Chart



Distance Standard Deviation

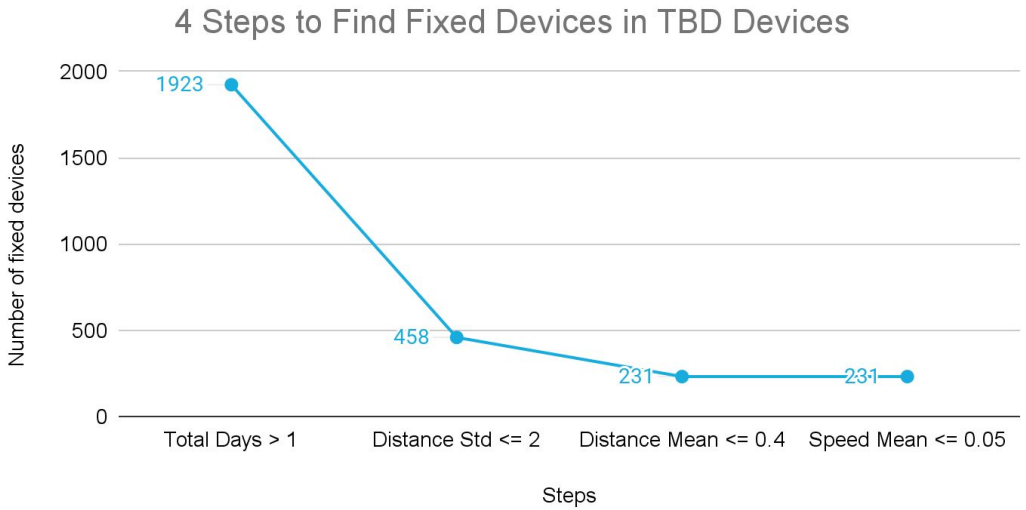


Distance Mean

How Do We Find Fixed Devices:
Distance, Speed and Number of Days Impact Device Classification

A **Fixed Device** should:

- Appears more than 1 day in total
- Distance Standard deviation <= 2
- Distance Mean <= 0.4
- Speed Median <= 0.05



Takeaways:

- 600 fixed devices in total
- 89.23% of all devices are mobile

Visitors, Security Guards and Daytime Workers use Mobile Devices

Visitors

Appears less than 10 days in total

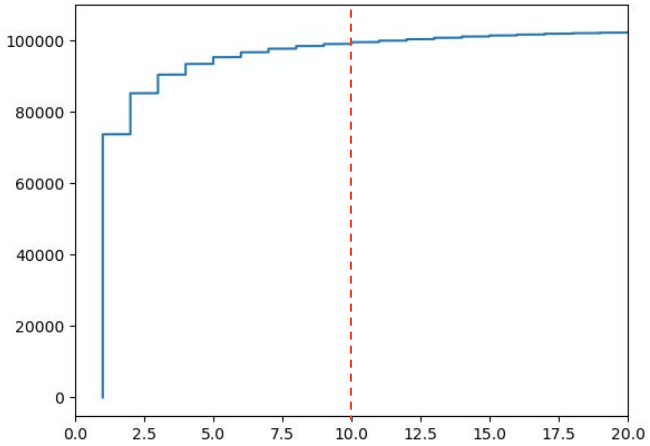
Security Guards

Appears at night (22:00-7:00) or on weekends

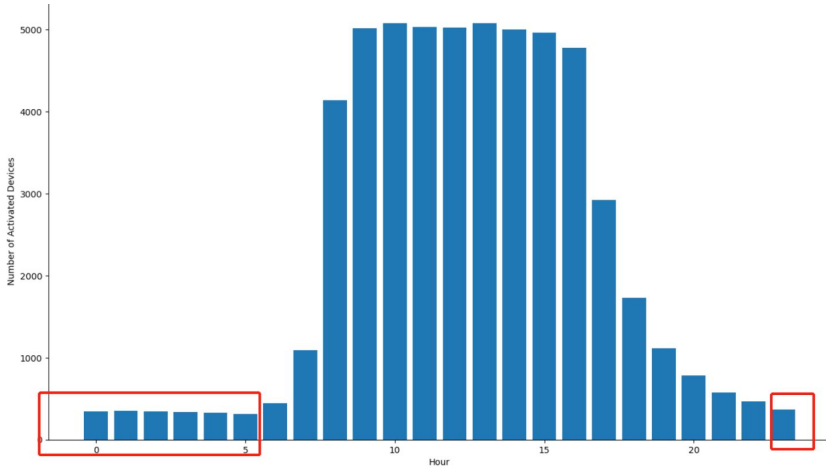
Daytime Workers

Other mobile devices

1. Scientists
2. Manufacturing Technicians
3. Facility Managers
4. Bioproduction Technologists
5. Production Operators



Total Days
Cumulative Distribution Chart



Hourly Distribution of Active Devices
(Security Guards and Daytime workers)

9 External Databases are Needed in the System

Security Area

SecurityArea	ZoneID	AccessLevel	Level
data_center	308	3	3rd Floor
data_center	307	3	3rd Floor

Surveillance Camera List

Camera ID	Level	ZoneID	SecurityArea
camera1	3rd Floor	307	data_center

Equipment Information

EquipmentID	ClientMacAddr	Process	ZoneID
P001	00:28:f8:26:ae:e4	Chemical Processing	107
P002	10:02:b5:e3:09:a9	Biological Fermenters	375

Surveillance Camera Photo Storage

Camera ID	photo	time
camera1	IMG_20190813_001007.JPG	2019-08-13 00:10:07
camera1	IMG_20190813_002017.JPG	2019-08-13 00:20:17

Stair Information

StairID	ZoneID	Level
A1	5	Ground Floor
A2	261	Ground Floor

Employee Identity

EmployeeID	EmployeeName	EmployeeRole	Email	ClientMacAddr
1029	Giulia Garcia	Production Operator	giulia.garcia@company.com	80:58:f8:38:3c:47
1013	Roberto Gutierrez	Security Guard	roberto.gutierrez@company.com	08:f6:9c:14:24:1b

Authorized Device

ZoneID	ClientMacAddr	Level
123	9c:da:3e:6a:d2:63	3rd Floor
124	9c:da:3e:6a:d2:63	3rd Floor

Employee Action

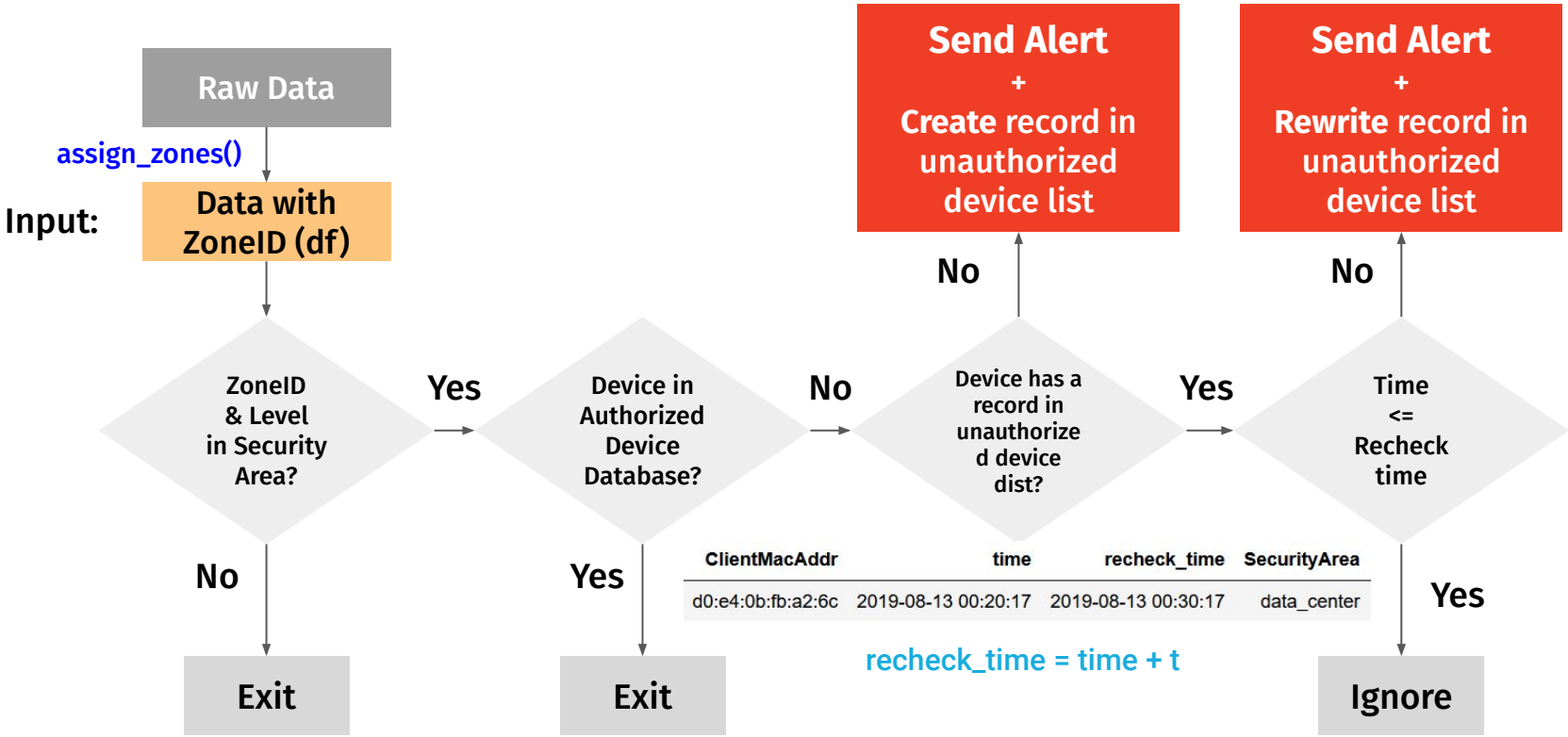
EquipmentState	Process	EmployeeRole	Action	Priority
Hazardous Leak	Chemical Processing	Scientist	• Ring alarm • Email / Text • Shutdown	High
Hazardous Leak	Chemical Processing	Bioproduction Technologist	• Ring alarm • Email / Text • Shutdown	High

Equipment Status

EquipmentID	EquipmentState	localtime	lat	lng	Prority	Process	Level
P001	Hazardous Leak	2019-08-13 10:58:07	51.460469	-0.93296	High	Chemical Processing	3rd Floor
P002	Calibration Needed	2019-08-13 10:58:07	51.460377	-0.933075	Medium	Biological Fermenters	3rd Floor

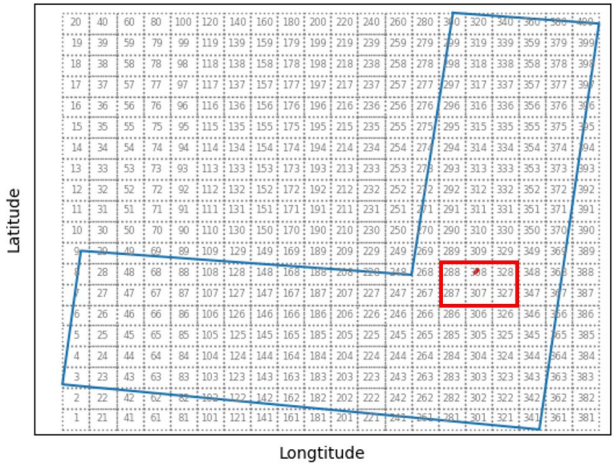
How Does Safe Sphere Detect Unauthorized Access?

```
def check_device_access(df, security_area, authorized_device, unauthorized_device, t)
```



Safe Sphere Waits t Minutes before Sending Next Alert

ClientMacAddr	localtime	Site	Level	lat	lng	ZoneID
d0:e4:0b:fb:a2:6c	2019-08-13 00:10:07	UK Office	3rd Floor	51.460523	-0.932417	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:10:17	UK Office	3rd Floor	51.460521	-0.932417	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:10:27	UK Office	3rd Floor	51.460523	-0.932417	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:10:37	UK Office	3rd Floor	51.460518	-0.932422	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:10:47	UK Office	3rd Floor	51.460519	-0.932421	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:10:57	UK Office	3rd Floor	51.460519	-0.932421	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:20:07	UK Office	3rd Floor	51.460523	-0.932417	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:20:17	UK Office	3rd Floor	51.460521	-0.932417	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:20:27	UK Office	3rd Floor	51.460523	-0.932417	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:20:37	UK Office	3rd Floor	51.460518	-0.932422	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:20:47	UK Office	3rd Floor	51.460519	-0.932421	308
d0:e4:0b:fb:a2:6c	2019-08-13 00:20:57	UK Office	3rd Floor	51.460519	-0.932421	308



= Security Area

• = rogue device

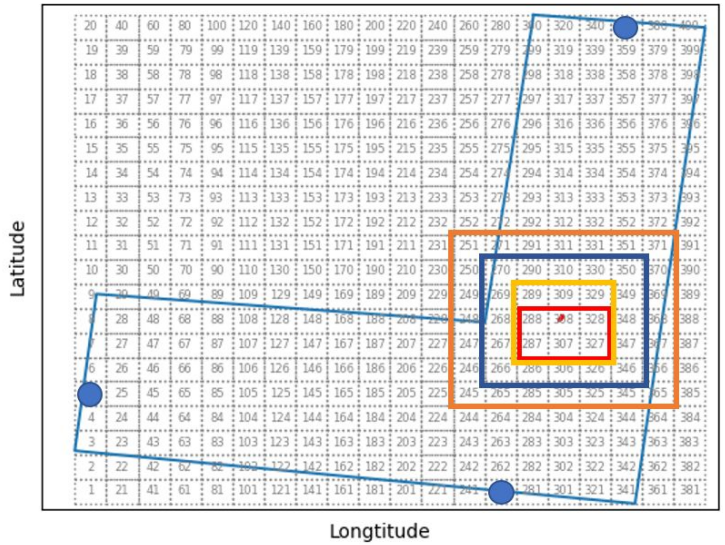
Only sends 1 alert per 10 minutes

```
1  check_device_access(rougue, security_area, authorized_device, unauthorized_device, t=10)
```

	ClientMacAddr	localtime	Site	Level	lat	lng	ZoneID	SecurityArea	alert
0	d0:e4:0b:fb:a2:6c	2019-08-13 00:10:07	UK Office	3rd Floor	51.460523	-0.932417	308	data_center	Detected unauthorized access by d0:e4:0b:fb:a2...
1	d0:e4:0b:fb:a2:6c	2019-08-13 00:20:17	UK Office	3rd Floor	51.460521	-0.932417	308	data_center	Detected unauthorized access by d0:e4:0b:fb:a2...

How Does Safe Sphere Find the Nearest Security Guard?

How does Safe Sphere search on the same floor?




```
def search_floor(k,floor,xx,yy):
    for i in range(xx-k,xx+k+1):
        for j in range(yy-k,yy+k+1):
            if isPoiWithinPoly(i,j,poly)==True:
                print(i,j)
                if list[floor-1][i][j]==1:
                    return (i,j)
    return 0
```

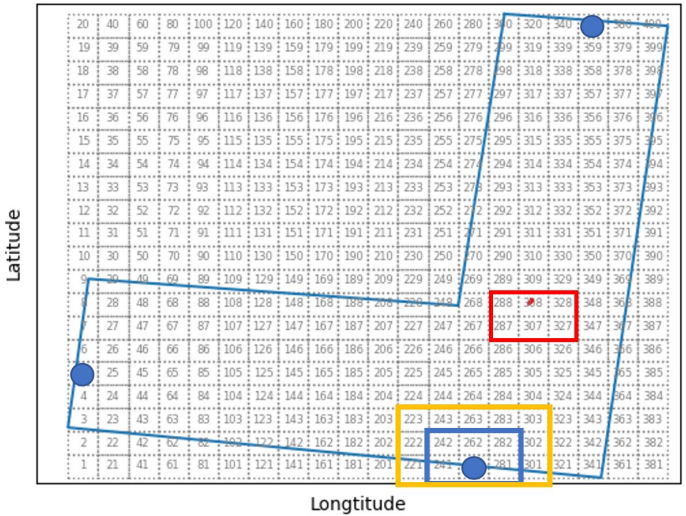
= Security Area

• = Unauthorized device

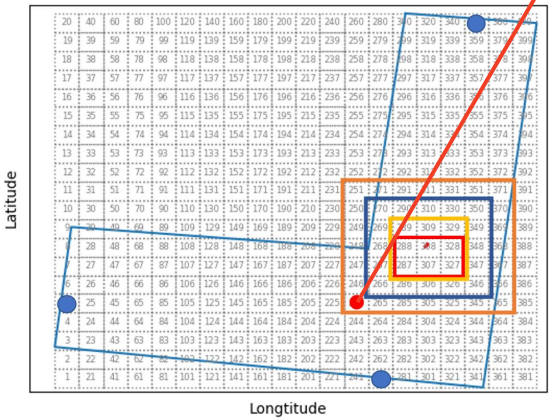
= Stairs

```
if m==1:
    #print(k-sub)
    if floor + 1 < 4:
        id = search_floor(k - sub, floor + 1,stairx,stairy)
        if id != 0:
            return id
    if floor - 1 >=0:
        id = search_floor(k - sub, floor - 1,stairx,stairy)
        if id != 0:
            return id
```

How does Safe Sphere search when finding a stair?



How Does Safe Sphere Alert the Nearest Security Guard?




```
security_guard = employee_identity[employee_identity['ClientMacAddr'].isin(macid['ClientMacAddr'])]
security_guard
```

	EmployeeID	EmployeeName	EmployeeRole	Email	ClientMacAddr
29	1007	Yuki Yamamoto	Security Guard	yuki.yamamoto@company.com	4c:56:9d:75:d1:e5

```
def security_email_content (security_guard, device):
    for i, row in security_guard.iterrows():
        print('Send to:' + row['Email'])
        employee_message = f"Dear {row['EmployeeName']}, \n"
        print(employee_message)
    for i, row in device.iterrows():
        alert_message = f"An unauthorized device ({row['ClientMacAddr']}) appears in the {row['SecurityArea']} at {row['time'
        print(alert_message)
        print('Please investigate on-site as soon as possible!')
def attach_photo(device, camera, photo):
    find_camera = pd.merge(device, camera, on='SecurityArea')
    find_photo = pd.merge(find_camera, photo, on=["time","Camera ID"])
    print(find_photo["photo"][0])
```

Security Alert

Send to: yuki.yamamoto@company.com
Dear Yuki Yamamoto,

An unauthorized device (d0:e4:0b:fb:a2:6c) appears in the data_center at 2019-08-13 00:20:17.
The location is 3rd Floor, and the zone id is 308.

Please investigate on-site as soon as possible!

Yes, I confirm. | Thank you for informing me. | No, it's not.

Reply | Forward


```
%%time
CPU times: total: 1min 7s
```

Smart Maintenance Detects & Prioritize Equip Abnormalities

Equipment Status

EquipmentID	EquipmentState	localtime	lat	lng	Prority	Process	Level
P001	Hazardous Leak	2019-08-13 10:58:07	51.460469	-0.93296	High	Chemical Processing	3rd Floor
P002	Calibration Needed	2019-08-13 10:58:07	51.460377	-0.933075	Medium	Biological Fermenters	3rd Floor
P003	Normal	2019-08-13 10:58:07	51.460371	-0.932919		Capsule Printing	3rd Floor
P004	Regular Maintenance Neede	2019-08-13 10:58:07	51.460387	-0.932712	Low	Fill / Label / Package	3rd Floor

Prioritize Maintenance Needs

```
for i in range(equip_status.shape[0]):
    if equip_status.iloc[i][2]==time and equip_status.iloc[i][1]!='Normal':
        if equip_status.iloc[i][5]=='Low':
            low=low+1
            j=0
        elif equip_status.iloc[i][5]=='Medium':
            med=med+1
            j=low
        elif equip_status.iloc[i][5]=='High':
            j=low+med
        list_id.insert(j,equip_status.iloc[i][0])
```

Employee Action

EquipmentState	Process	EmployeeRole	Action	Priority
Hazardous Leak	Chemical Processing	Scientist	• Ring alarm • Email / Text • Shutdown	High

How Does Smart Maintenance Alert Employee?

	EquipmentID	ClientMacAddr
0	P001	88:b4:a6:49:88:11
1	P002	80:58:f8:5a:0d:88
2	P004	80:58:f8:38:3c:47

```python
def employee_email_content (equip_employee_action):
    for i, row in equip_employee_action.iterrows():
        print('Send to:' + row['Email'])
        employee = f"Dear {row['EmployeeRole']} {row['EmployeeName']}, \n"
        print(employee)
        alert = f"The state of equipment ({row['EquipmentID']}) changes to {row['EquipmentState']} at {row['localtime']}."
        print(alert)
        print('The priority is ' + row['Priority'] + '.')
        location = f"The location is {row['Level']}, and the zone id is {row['ZoneID']}."
        print(location)
        action = f"What you need to do is the following step(s): \n{row['Action']} \n"
        print(action)
        print('Please investigate on-site as soon as possible! \n\n')
```

Maintenance Alert

Send to: luca.rossi@company.com
Dear Scientist Luca Rossi,

The state of equipment (P001) changes to Hazardous Leak at 2019-08-13 10:58:07.
The priority is High.
The location is 3rd Floor, and the zone id is 107.
What you need to do is the following step(s):
- Ring alarm
- Email / Text
- Shutdown

Please investigate on-site as soon as possible!

Reply Forward

Maintenance Alert

Send to: sofia.smith@company.com
Dear Bioproduction Technologist Sofia Smith,

The state of equipment (P002) changes to Calibration Needed at 2019-08-13 10:58:07.
The priority is Medium.
The location is 3rd Floor, and the zone id is 375.
What you need to do is the following step(s):
- Notice of schedule

Please investigate on-site as soon as possible!

Reply Forward

Maintenance Alert

Send to: giulia.garcia@company.com
Dear Production Operator Giulia Garcia,

The state of equipment (P004) changes to Regular Maintenance Needed at 2019-08-13 10:58:07.
The priority is Low.
The location is 3rd Floor, and the zone id is 360.
What you need to do is the following step(s):
- Refresh Maintenance Log

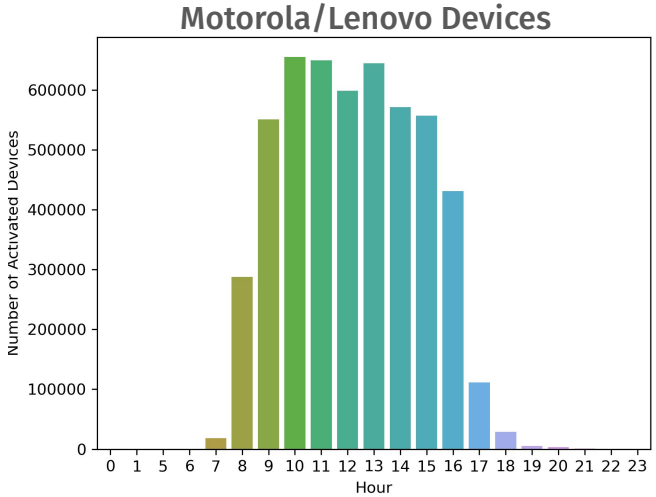
Please investigate on-site as soon as possible!

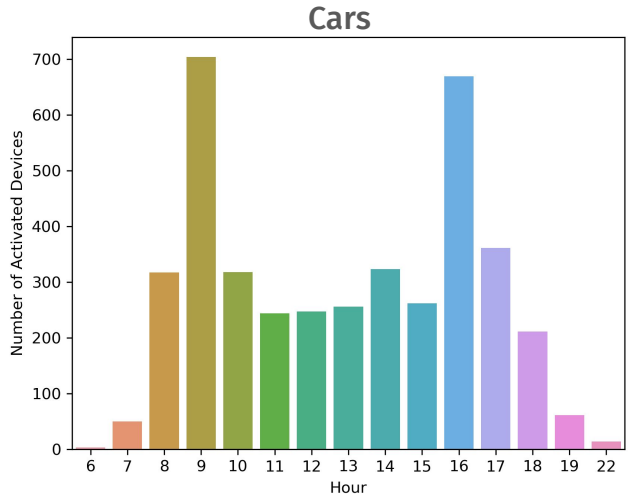
Reply Forward

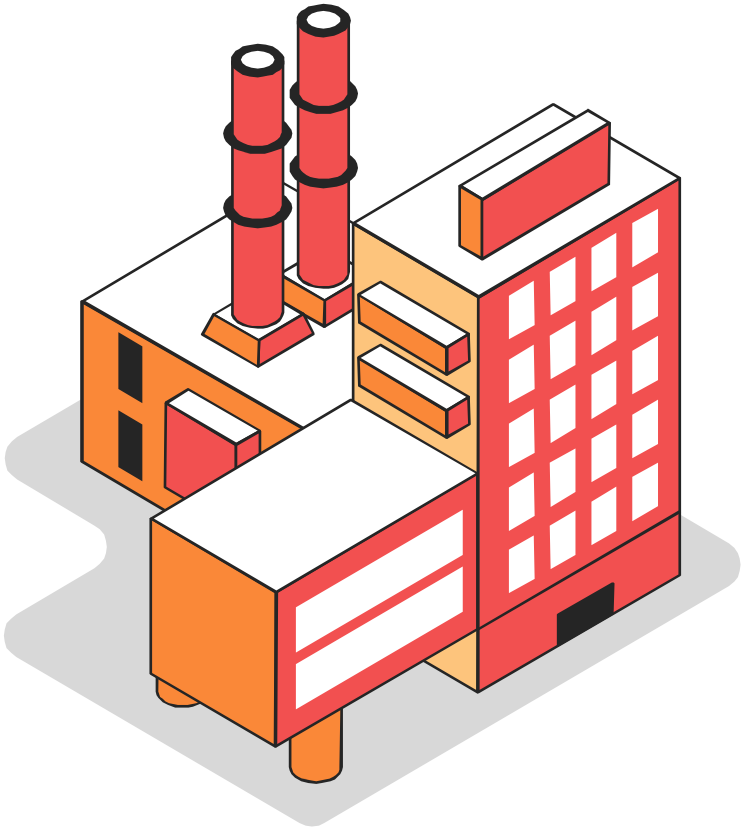
Sanofi UK Workers Barely Work Overtime

Rank	Manufacturer	Count
1	Motorola Mobility LLC, a Lenovo Company	102252
2	Apple, Inc.	3655
3	SAMSUNG ELECTRO-MECHANICS(THAILAND)	1446
4	Samsung Electronics Co.,Ltd	1252
5	HUAWEI TECHNOLOGIES CO.,LTD	480

Manufacturer	Sub_Type
Continental Automotive Czech Republic s.r.o.	Car
ACTIA	Car
Pittasoft	Car
Visteon Corporation	Car
Ford Motor Company	Car
SmartDrive Systems Inc.	Car







Thank you!
Q&A

Reference

Association of Certified Fraud Examiners. “2020 Global Study on Occupational Fraud and Abuse,”https://acfepublic.s3-us-west-2.amazonaws.com/2020-Report-to-the-Nations.pdf.

Senseye. “The True Cost of Downtime 2022.” November 2022, https://www.senseye.io/blog/the-true-cost-of-downtime-2022.