CARLOS III UNIVERSITY OF MADRID

HIGHER TECHNICAL SCHOOL



MASTER IN CYBERSECURITY

MASTER THESIS

TARGETED EXERCISER FOR ANDROID MALWARE AND GRAYWARE

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**Abstract**

Nowadays each person has one or more mobile device (smartphones, tablets, wearables, etc) with similar characteristics and performance of a personal computer. Many people use these devices to check their email or make bank transfers. For this, these devices store a lot of sensitive information that it could be very attractive to an attacker.

Mobile devices share same security troubles can be found in a conventional computer as malware hidden inside apps or users that don’t use nor protect their correctly.

Malware has evolved and is able to by pass protection systems and works only under certain circumstances to avoid detection. Some kind of malware is activated depends of network connection, device location, apps installed, calls received or other type of events.

The purpose of this Master Thesis is to study the behavior of malware on mobile devices depending of the device context, focusing on Android operating system. It has developed a system that allows dynamic and automatic generation of many different contexts to study the behavior of Android malware in each of the scenarios.

It has been designed a technique based on new language which defines each of the scenes and events to execute over the device to analyze the malware, in order to study their behavior depending on the characteristics of each context. In this way, it can detect the context features that makes triggering the malicious malware or greyware actions.

This Thesis focuses on analyzing all possible Android events to define a language and developing a system available to understand it and generate automatic executions to launch these events. With this system it is possible detect malware and grayware that a convetional static and dynamic analysis could not detect.

*Keywords: Malware, Greyware, Android, Context, Malware detection, Dynamic analysis, Mobile device*

1. **Introduction**

Los dispositivos móviles se han expandido notablemente en la sociedad actual. La mayoría de las personas posee uno o más dispositivos móviles (graficas de uso de dispositivos móviles) de los cuales Android es un porcentaje importante.

Se bajan no se cuantas aplicaciones de Android al día. Actualmente esto supone una atractiva puerta para los atacantes para introducir código malicioso en apks que aparentan ser legítimas (ejemplo de pokemon go). Muchos de los atacantes se centran en focalizar sus actividades maliciosas en usuarios que cumplen una serie de características o tienen un hábito de consumo y uso del dispositivo móvil determinado.

1. *Motivation*
2. *Main contributions*
3. *Structure of the document*
4. **Related Work**
5. **TargetDroid**
6. *What is?*
7. *Events*
8. *Contexts (t= -1, t = 0, t > 0)*
9. **Discussion**
10. **Conclusion**
11. **Future Works**

**References**

**Appendix A : json-schema**

**{**

**"$schema": "http://json-schema.org/draft-04/schema#",**

**"id": "input JSON to configure a scenario and launch android events",**

**"type": "object",**

**"required": ["name", "time"]**

**"properties": {**

**"name":{**

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**},**

**"time": {**

**"id": "definition of context in every execution time",**

**"type": "object",**

**"oneOf": [**

**{**

**"type": "object",**

**"required": ["id"],**

**"properties": {**

**"id": {**

**"id": "execution time",**

**"type": "integer",**

**"enum": [-1]**

**},**

**"emulator": {**

**"id": "emulator configuration params",**

**"properties": {**

**"name": {**

**"id": "emulator name",**

**"type": "string"**

**},**

**"port": {**

**"id": "emulator port",**

**"type": "integer"**

**},**

**"sdk\_version": {**

**"id": "emulator android version",**

**"type": "string",**

**"enum":["android-8", "android-10", "android-15", "android-16", "android-17", "android-18", "android-19", "android-20", "android-21", "android-22", "android-23"]**

**}**

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**},**

**"phone": {**

**"id": "phone properties",**

**"type": "object",**

**"properties": {**

**"brand": {**

**"id": "phone brand name",**

**"type": "string"**

**},**

**"device": {**

**"id": "phone device name",**

**"type": "string"**

**},**

**"hardware": {**

**"id": "phone hardware name",**

**"type": "string"**

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**"type": "string"**

**},**

**"imsi": {**

**"id": "phone imsi",**

**"type": "string"**

**},**

**"network\_provider": {**

**"id": "phone network provider name",**

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**}**

**}**

**},**

**"network": {**

**"id": "network properties",**

**"type": "object",**

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**"IP": {**

**"id": "phone IP",**

**"type": "string"**

**},**

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**"id": "phone DNS server",**

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**"id": "The CPU model (QEMU-specific string)",**

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**"main\_keys": {**

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**"id": "Track-ball support",**

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**"keyboard\_lid": {**

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**"id": "Name of the system keyboard charmap file",**

**"type": "string"**

**},**

**"d\_pad": {**

**"id": "Whether the device has DPad keys",**

**"type": "boolean"**

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**"gsm\_modem": {**

**"id": "phone DNS server",**

**"type": "string"**

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**"gps": {**

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**"type": "boolean"**

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**"battery": {**

**"id": "Whether the device can run on a battery",**

**"type": "boolean"**

**},**

**"accelerometer": {**

**"id": "Whether there is an accelerometer in the device",**

**"type": "boolean"**

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**"audio\_input": {**

**"id": "Whether the device can record audio",**

**"type": "boolean"**

**},**

**"audio\_output": {**

**"id": "Whether the device can play audio",**

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**"sd\_card": {**

**"id": "Whether the device supports insertion/removal of virtual SD Cards",**

**"type": "boolean"**

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**"sd\_card\_path": {**

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**"lcd\_height": {**

**"id": "LCD pixel height",**

**"type": "integer"**

**},**

**"lcd\_depth": {**

**"id": "LCD color depth",**

**"type": "integer"**

**},**

**"lcd\_density": {**

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**"type": "integer"**

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**"id": "LCD backlight",**

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**},**

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**"camera\_front": {**

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**"id": "Provides orientation sensor values",**

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**"sensor\_temperature": {**

**"id": "Provides temperature sensor values",**

**"type": "boolean"**

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**"kernel\_parameters": {**

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**"system\_partition\_size": {**

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**"type": "integer"**

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**"id": "telnet commands",**

**"type": "object",**

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**"type": "object",**

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**"capacity": {**

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**"type": "integer"**

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**"health": {**

**"id": "power health properties",**

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**"type": "boolean"**

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**"status": {**

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**"id": "power properties",**

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**"properties": {**

**"ac": {**

**"id": "ac properties",**

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**"health": {**

**"id": "power health properties",**

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**},**

**"present": {**

**"id": "battery presence",**

**"type": "boolean"**

**},**

**"status": {**

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**},**

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**"type": "object",**

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**"call": {**

**"id": "call to a number",**

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**},**

**"accept": {**

**"id": "accept a call",**

**"type": "string"**

**},**

**"busy": {**

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**"type": "string"**

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**"cancel": {**

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**"type": "string"**

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**"voice": {**

**"id": "voice connection status",**

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**"properties": {**

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**"id": "number phone to send a sms",**

**"type": "string"**

**},**

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**"id": "location events",**

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**"fix": {**

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**"type": "object",**

**"properties": {**

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**},**

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**"type": "string"**

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**"altitude": {**

**"id": "altitude",**

**"type": "string"**

**},**

**"required": [ "longitude", "latitude" ]**

**}**

**},**

**"nmea": {**

**"id": "nmea",**

**"type": "string"**

**}**

**}**

**}**

**}**

**},**

**"adb": {**

**"id": "adb popular commands",**

**"type": "array",**

**"properties": {**

**"action": {**

**"id": "adb action name",**

**"type": "string",**

**"enum": ["connect\_wifi", "lock\_screen", "unlock\_screen", "volume\_up", "go\_home", "take\_screenshot", "start\_clock\_app", "stop\_clock\_app", "start\_wifi", "wifi\_status", "enable\_wifi", "disable\_wifi", "enable\_mobile\_data", "disable\_mobile\_data"]**

**}**

**}**

**},**

**"intents": {**

**"id": "intents commands",**

**"type": "array",**

**"properties": {**

**"type": {**

**"id": "intent type",**

**"type": "string",**

**"enum": ["start", "start\_service", "broadcast"]**

**},**

**"params": {**

**"id": "intent params",**

**"type": "string"**

**}**

**}**

**},**

**"monkey": {**

**"id": "monkey script events",**

**"type": "object",**

**"properties": {**

**"path":{**

**"id": "path to monkey script",**

**"type": "string"**

**},**

**"package": {**

**"id": "apk package where run monkey script",**

**"type": "string"**

**}**

**}**

**}**

**}**

**}**

**]**

**}**

**}**

**}**

**Appendix B: event list**

# Eventos de configuración del entorno

|  |  |  |
| --- | --- | --- |
| Atributo | Valores | Descripción |
| emulator |  |  |
| Emuator.name | String | Nombre del AVD a crear |
| Emulator.port | Integer | Puerto en el que escuchará el AVD |
| Emulator.sdk\_version | String  "enum":[  "android-8", "android-10", "android-15", "android-16", "android-17", "android-18", "android-19", "android-20", "android-21", "android-22", "android-23"] | Versión del Android SDK utilizado por el emulador |
| phone |  | |
| phone.brand | string | Indica la marca comercial del dispositivo emulado |
| phone.device | String | Indica el modelo del dispositivo emulado |
| phone.imei | String | Indica el valor IMEI que tendrá el dispositivo emulado. |
| Phone.imsi | String | Indica el valor IMSI que tendrá el dispositivo emulado. |
| Phone.provider | string | Indica el nombre del proveedor de red del emulador |
| Network |  | |
| Network.IP | String | Indica la dirección IP del dispositivo emulado |
| Network.DNS | string | Indica las direcciones DNS a utilizar por el dispositivo emulado. Puede ser una lista de hasta cuatro direcciones IP o hostnames separado por comas. |
| ini\_properties |  |  |
| ini\_properties. cpu\_arch | String | Indica el tipo de la arquitectura de la CPU del emulador. |
| ini\_properties. cpu\_model | String | Indica el modelo de la CPU |
| ini\_properties. ram\_size | Integer | Indica el tamaño de la memoria RAM |
| ini\_properties. screen\_type | String  "enum":[  "touch",  "multi-touch", "no-touch"] | Define el tipo de pantalla |
| ini\_properties. main\_keys | Boolean | Activa/desactiva los botones de Volver/Inicio |
| ini\_properties keyboard | Boolean | Indica si el emulador utiliza es un teclado QWERTY |
| ini\_properties.keyboard\_lid | Boolean | Permite abrir el teclado QWERTY o no |
| ini\_properties.keyboard\_charmap | string | Nombre del sistemat charmap del teclado |
| ini\_properties.d\_pad | Boolean | Indica si el dispositivo presenta teclas DPad |
| ini\_properties.gsm\_modem | String | Indica el módem GSM del dispositivo |
| ini\_properties.gps | Boolean | Indica la presencia de GPS en el dispositivo |
| ini\_properties.battery | Boolean | Indica la presencia de batería en el dispositivo |
| ini\_properties.accelerometer | Boolean | Indica la presencia de acelerómetro en el dispositivo |
| ini\_properties.audio\_input | Boolean | Indica la pesencia de entrada de audio en el dispositivo |
| ini\_properties.audio\_output | Boolean | Indica a presencia de salida de audio en el dispositivo |
| ini\_properties.sd\_card | Boolean | Indica si el dispositivo soporta el uso de tarjetas SD |
| ini\_properties.sd\_card\_path | String | Presenta la ruta de la imagen de la tarjeta SD a utilizar |
| ini\_properties.cache | Boolean | Indica el uso de una partición cacheada en el dispositivo |
| ini\_properties.cache\_path | String | Presenta la ruta de la cache a utilizar |
| ini\_properties.cache\_size | String | Es el valor del tamaño de la caché |
| ini\_properties.lcd\_width | Integer | Ancho del pixel LCD |
| ini\_properties.lcd\_height | Integer | Alto del pixel LCD |
| ini\_properties.lcd\_depth | Integer | Profundidad de color LCD |
| ini\_properties.lcd\_density | Integer  "enum":[  120,  160,  240,  213,  320 | Densidad LCD |
| ini\_properties.lcd\_backlight | Boolean | Presencia de LCD Backlight |
| ini\_properties.gpu | Boolean | Indica el uso de una OpenGLES GPU emulada |
| ini\_properties.camera\_back | String | Configuración de la cámara trasera |
| ini\_properties.camera\_front | String | Configuración de la cámara frontal |
| ini\_properties.heap\_size | Integer | Define el tamaño máximo del heap del emulador |
| ini\_properties.sensor\_proximity | Boolean | Presencia de sensor de proximidad |
| ini\_properties. sensor\_magnetic\_field | Boolean | Presencia de sensor magnético |
| ini\_properties. sensor\_orientation | Boolean | Presencia de sensor de orientación |
| ini\_properties. sensor\_temperature | Boolean | Presencia de sensor de temperatura |
| ini\_properties. use\_ext4 | Boolean | Indica que sistema de ficheros utilizar:  Ext4/ yaffs2 |
| ini\_properties. kernel\_path | String | Presenta la ruta de la imagen del kernel a utilizar |
| ini\_properties. kernel\_parameters | String | Indica los parámetros a pasar al boot kernel |
| ini\_properties. system\_partition\_path | string | Indica la ruta de la partición del sistema |
| ini\_properties. system\_partition\_init\_path | String | Indica la ruta de la partición del sistema inicial |
| ini\_properties. system\_partition\_size | Integer | Tamaño del sistema de partición |
| ini\_properties. data\_partition\_path | String | Indica la ruta de la partición de datos |
| ini\_properties. data\_partition\_init\_path | String | Indica la ruta de la partición de datos inicial |
| ini\_properties. data\_partition\_size | Integer | Tamaño de la partición de datos |
| ini\_properties. snap\_storage\_path | String | Indica la ruta del snapshot a almacenar |

# Eventos de configuración inicial del contexto

|  |  |  |
| --- | --- | --- |
| Atributo | Valores | Descripción |
| Intall\_app | String | Instala la apk indicada (acepta el path) |
| Timezone | string | Configura la franja horaria del dispositivo |
| power |  | |
| power.ac | On  off | Indica si el dispositivo está conectado a la corriente eléctrica |
| Power.capacity | integer | Indica la capacidad de carga de la batería |
| Power.health | Unknown  Good  Overheat  Dead  Overvoltage  failure | Indica el estado de salud de la batería |
| Power.present | Boolean | Indica la presencia de batería o no en el dispositivo |
| Power.status | Unknown  Charging  Discharging  not-charging  full | Indica el estado de la batería |

# Eventos de configuración de contexto

|  |  |  |
| --- | --- | --- |
| Atributo | Valores | Descripción |
| power |  | |
| power.ac | On  off | Indica si el dispositivo está conectado a la corriente eléctrica |
| Power.capacity | integer | Indica la capacidad de carga de la batería |
| Power.health | Unknown  Good  Overheat  Dead  Overvoltage  failure | Indica el estado de salud de la batería |
| Power.present | Boolean | Indica la presencia de batería o no en el dispositivo |
| Power.status | Unknown  Charging  Discharging  not-charging  full | Indica el estado de la batería |
| Gsm |  | |
| Gsm.Call | String | Llamada al número indicado |
| Gsm.Accept | String | Acepta una llamada desde el número indicado |
| Gsm.Busy | String | Rechaza una llamada desde el número indicado |
| Gsm.Cancel | String | Cancela una llamada desde el número indicado |
| Gsm.Data | Unregistered  Home  Roaming  Searching  Denied  Off  on | Define el estado de la conexión de datos |
| Gsm.Voice | Unregistered  Home  Roaming  Searching  Denied  Off  on | Define el estado de la conexión de voz |
| Sms |  | |
| Sms.number | String | Indica el número al que se va a enviar el SMS |
| Sms.message | String | Contenido del SMS |
| Geo |  | |
| geo.fix.longitude | String | Indica la longitud en la geolocalización |
| geo.fix.latitude | String | Indica la latitud en la geolocalización |
| geo.fix.altitude | String | Indica la altitud en la geolocalización |
| Geo.nmea | String | Emulación NMEA |
| Intents |  |  |
| Intents.type | String | Tipo de intent |
| Intents.params | String | Parámetros del intent |
| Adb |  |  |
| Adb.action | String  Enum = [  “connect\_wifi”,  “lock\_screen”,  “unlock\_screen”,  “volumen\_up”,  “go\_home”,  “take\_screenshot”,  “start\_clock\_app”,  “stop\_clock\_app”,  “start\_wifi”,  “enable\_wifi”,  “wifi\_status”,  “enable\_mobile\_data”,  “disable\_mobile\_data”  ] | Tipo de comando a ejecutar |
| Monkey |  |  |
| Monkey.path | String | Path del script monkey |
| Monkey.package | String | Package sobre el que se ejecutará el script |

**Appendix C: Planning and budget**

In order to comply with the regulations of MsC Thesis by Universidad Carlos III de Madrid, this appendix presents the Planning and Budget of the Thesis.

First, it is going to be presented a planning that defines this project in different tasks. It has been generated a typical Gantt chart presenting in a graphical form the duration of each phase.

The resume of the phases is shown in Figure X with its start and end date. Gantt chart with detailed information is shown in Figure X+1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Duration (days) | Start Date | End Date |
| Definition of goals | 27 | 16/01/2016 | 23/02/2016 |
| Analysis | 34 | 01/03/2016 | 15/04/2016 |
| Design | 14 | 24/05/2016 | 10/06/2016 |
| Development | 16 | 13/06/2016 | 04/07/2016 |
| Testing | 4 | 5/07/2016 | 10/07/2016 |
| Report | 34 | 18/07/2016 | 1/09/2016 |





Last, it is going to be presented the budget. It is broken down into various estimations by type cost:

* Personal cost: 31.600 €
* Hardware cost: 30 €
* Software cost: 0 €
* Indirect cost: 301 €
* Total cost: 31.600 €

Note: VATs are included.

|  |  |  |  |
| --- | --- | --- | --- |
| Concept | Time (hours) | Fees | RRHH cost |
| Security Engineer | 500 | 50 €/hour | 25.000 € |
| PhD | 120 | 55 €/hour | 6.600 € |
| TOTAL | | | 31.600 € |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Concept | Units | Unit price | Estimated life time | Airtime (months) | Cost |
| Acer Aspire 5740 | 1 | 600 € | 60 months | 4,3 | 30 € |
| TOTAL | | | | | 30 € |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Concept | Units | Unit price | Estimated life time | Airtime | Cost |
| Ubuntu Linux | 1 | 0 € | - | 4,3 | 0 € |
| Sublime Text 3 | 1 | 0 € | - | 4,3 | 0 € |
| SmartGit Hg 7.1 | 1 | 0 € | - | 4,3 | 0 € |
| Github | 1 | 0 € | - | 4,3 | 0 € |
| Bitbucker | 1 | 0 € | - | 4,3 | 0 € |
| MiKTeX | 1 | 0 € | - | 4,3 | 0 € |
| TeXnic Center | 1 | 0 € | - | 4,3 | 0 € |
| Adobe Reader | 1 | 0 € | - | 4,3 | 0 € |
| Google Chrome | 1 | 0 € | - | 4,3 | 0 € |
| TOTAL | | | | | 0 € |

|  |  |  |  |
| --- | --- | --- | --- |
| Concept | Monthly price | Airtime (months) | Cost |
| Electricity | 40 € | 4,3 | 172 € |
| Internet | 30 € | 4,3 | 129 € |
| TOTAL | | | 301 € |

|  |  |
| --- | --- |
| Concept | Amount |
| Personal cost | 31.600 € |
| Hardware cost | 30 € |
| Software cost | 0 € |
| Indirect cost | 301 € |
| TOTAL | 31.931 € |