



Dial M for Mixer

A Methodological Approach to Forensic Analysis of Unknown Devices Using the Thermomix TM6

Maximilian Eichhorn, Felix Freiling

November 11, 2025

IT Security Infrastructures Lab

Department of Computer Science

Friedrich-Alexander-Universität Erlangen-Nürnberg

Motivation

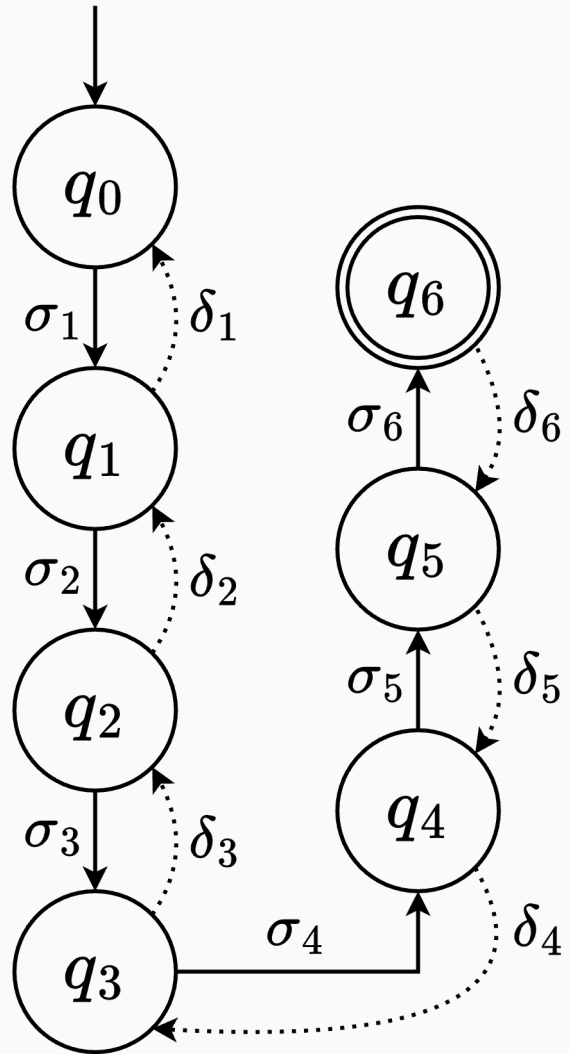
Obstacles in embedded device forensics:

- High number of unknown IoT or embedded devices
- Systematic forensic analysis process helpful
- Multiple challenges like data acquisition and encryption

Our methodology as possible generic starting point:

- Second device for systematic, practical test data generation
- Differential forensic analysis

Differential Forensic Analysis & State Machine



- States $q_i \in Q$
- State transitions $\sigma_i \in \Sigma$
- Deltas $\delta_i \in \Delta$

Thermomix TM6



techgadgetsCanada.com/review-thermomix-tm6-smart-cooking-robot/



thermomix.ca/products/tm6%C2%AE-sparkling-black

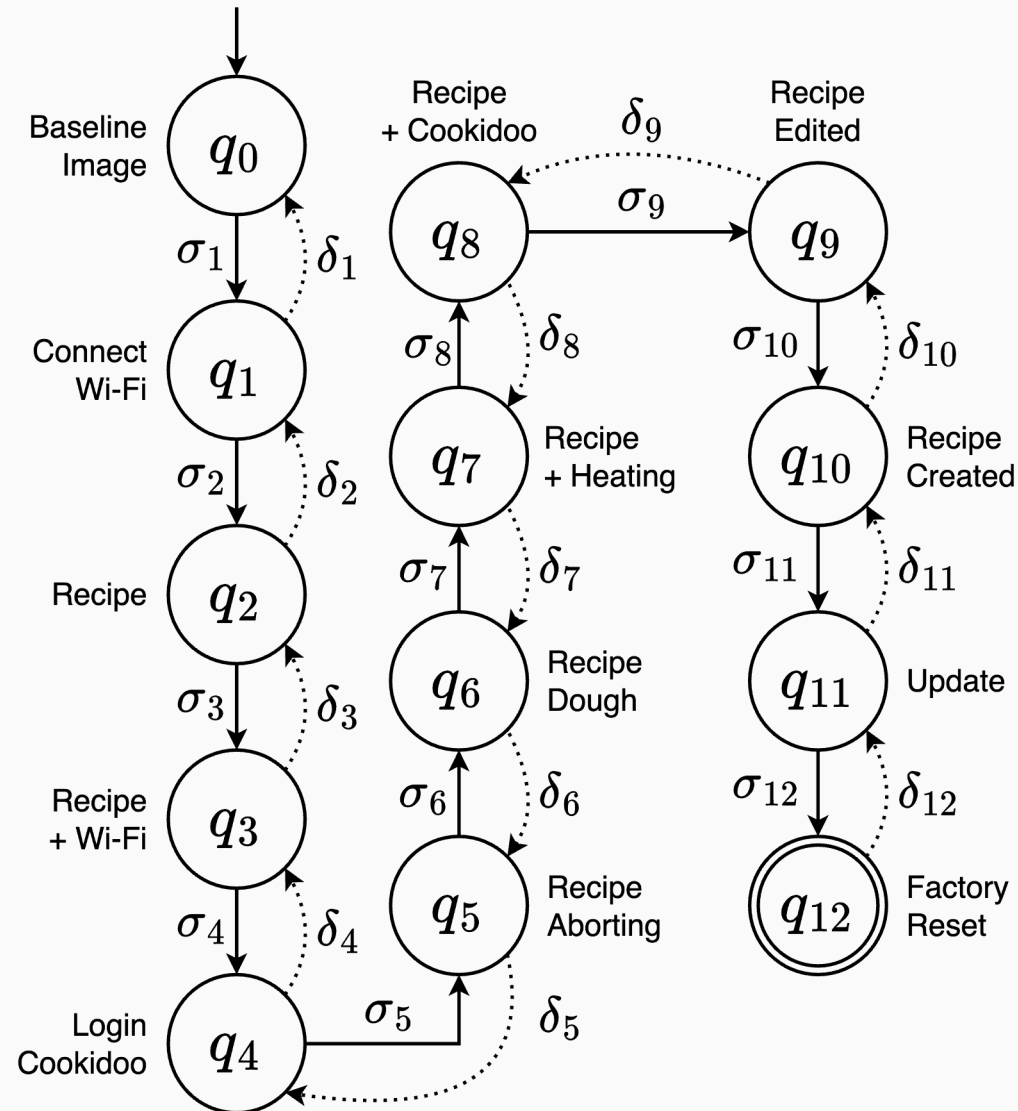
Thermomix TM6

- Kitchen appliance by Vorwerk released in 2019
- Wi-Fi 5
- Touchscreen & rotary knob
- Recipe platform Cookidoo



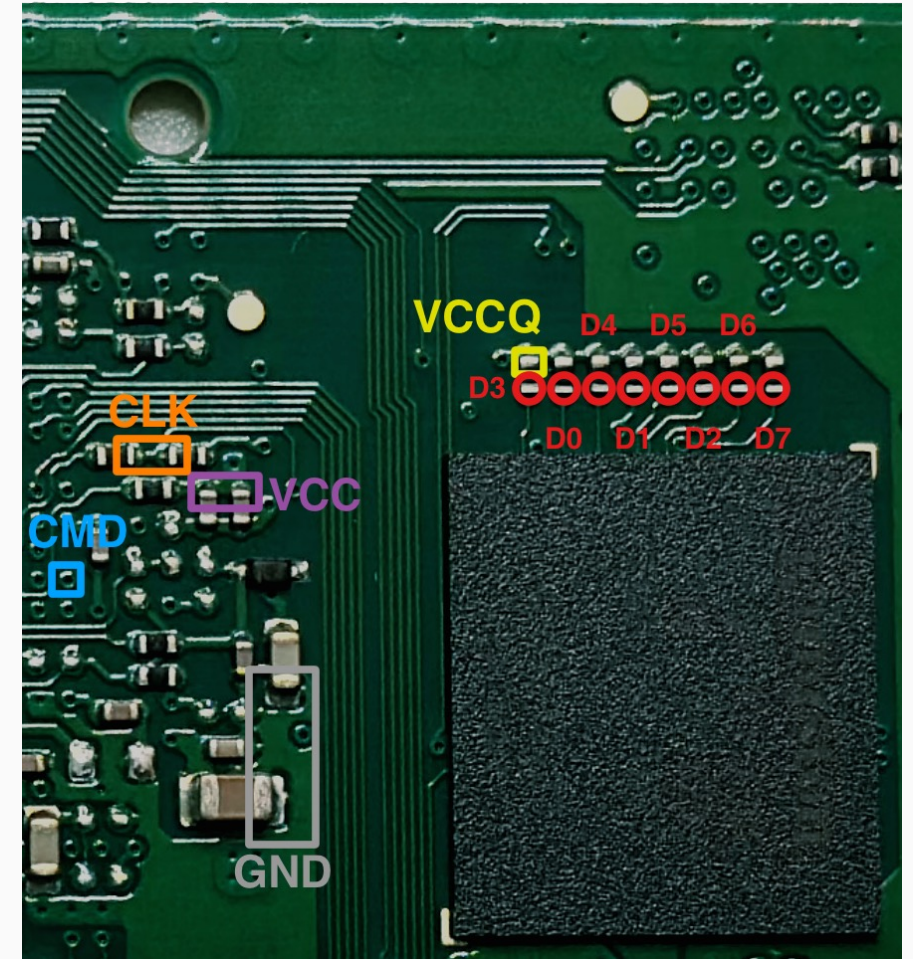
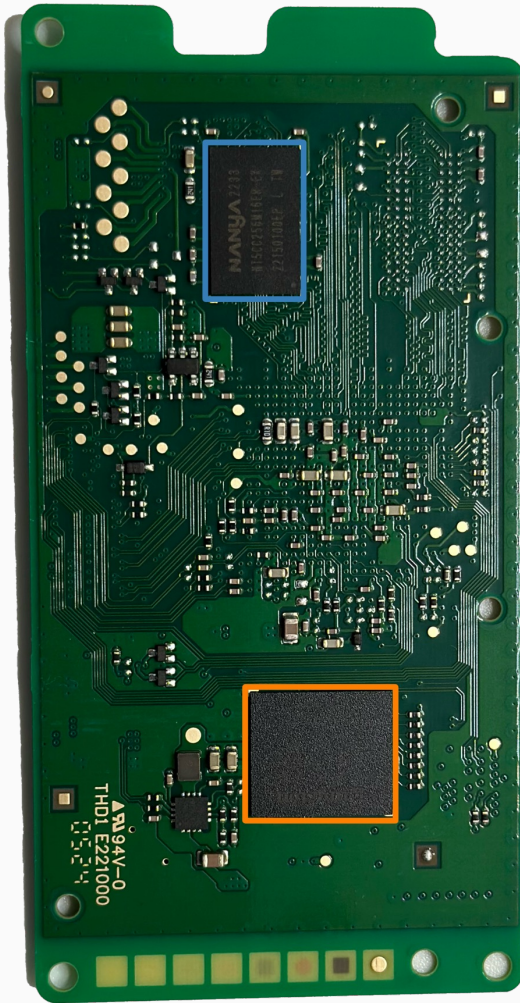
thermomix.ca/products/tm6%C2%AE-sparkling-black

State Machine



- States $q_i \in Q$
- State transitions $\sigma_i \in \Sigma$
- Deltas $\delta_i \in \Delta$

Data Acquisition



Partitions

Label HW	Label OS	Size MiB	FS Type	Notes
ROM1	uarea	13,416	LVM2	LVM2 with 2 LVs
	plain_uarea	3,069	BTRFS	User data
	enc_uarea	<7,700	LUKS1	Encrypted user data
ROM2	boot0	4	-	ARMv7 executable code
ROM3	boot1	4	-	ARMv7 executable code
RPMB	rpmb	4		Not readable (EasyJTAG)
GP1	gp0	512	-	Partition with GPT
	gp0p1	10		
	gp0p2	1	SquashFS	Some install scripts
	gp0p3	497	LVM2	LVM2 with 3 LVs
	gp0-rootfs	117	SquashFS	Root filesystem
	gp0-appfs1	137	LUKS1	Encrypted
	gp0-appfs2	94	LUKS1	Encrypted
GP2	gp1	512	-	Partition with GPT
	gp1p1	10		
	gp1p2	1	SquashFS	Some install scripts
	gp1p3	497	LVM2	LVM2 with 3 LVs
	gp1-rootfs	117	SquashFS	Root filesystem
	gp1-appfs1	137	LUKS1	Encrypted
	gp1-appfs2	94	LUKS1	Encrypted
GP3	gp2	512	-	Partition with GPT
	gp2p1	1		
	gp2p2	10	Ext4	Some .blob files
	gp2p3	497	LUKS1	Encrypted

- 7x HW partitions
- 3x LVM2
- 3x GPT partition tables
- 4x SquashFS
- 6x LUKS1 encrypted partitions

Forensic Artifacts – Wi-Fi & Cookidoo

- Wi-Fi credentials
- Cookidoo account information

```
1 //config/settings/common/wifi-manager/wifi-manager.conf
2 {"country_code":"[CC]",
3   "enabled":true, [...]
4   "last_connected":"[SSID]",
5   "networks": [{"enc":"WPA","enc_enabled":true,"
6                 psk":"[PSK]","ssid":"[SSID]"}]}
7 //config/state/defaultUser/auth-manager.conf
8 TRIAL "ACTIVE*2025-05-14T23:59:00Z2FULL:[EMAIL]B2025
9       -04-14T08:07:19JRZ?"
```

Forensic Artifacts – Systemd Journal

```
1 //device ID
2 Apr 14 10:05:20 imx6qmwot HardwareManager[627]:
  PublishSystemData: {"BE-HW-Version
    ":"218169344","BE-SERIAL-NO":"[BE-NO]","BE-
    SERIAL-NO-MASKED":"[BE-NO-MASKED]","[...]","COMM-
    SECRET":"0","DEVICE-ID":"[DEVICE-ID]","DEVICE-
    SERIAL-NO":"[DEVICE-NO]","SERIAL-NO-MASKED":"
    [DEVICE-NO-MASKED]","FE-SERIAL-NO":"[FE-NO]","FE-
    SERIAL-NO-MASKED":"[FE-NO-MASKED]","FE-SW-Version
    ":{"FE-SW-release_label":"202309261610","MAJOR
    ":4,"MINOR":0,"PATCH":6},"MAC-ADDRESS":"
    E02DF0A77221","UNIQUE-ID":"0000aae4e0c71cde","
    WIFI-DOMAIN":"0","WIFI-OFFLINE":0}
3
4 //heating
5 Apr 16 14:45:35 imx6qmwot cookingEngineManager[629]:
  updateHeatingActive -> foodTemperature: 37,
  targetTemperature: 80, running: 1
6 Apr 16 14:44:53 imx6qmwot cookingEngineManager[629]:
  setting heating active to true
7
8 //mixing
9 May 12 13:54:48 imx6qmwot cookingEngineManager[652]:
  Set speed: 2000
10 May 12 13:54:48 imx6qmwot cookingEngineManager[652]:
  Published motor current speed: 1986
```

- Device information
- Usage information
- Recipes from Cookidoo

Forensic Artifacts – Blackbox Files

- Directory blackbox
- CSV-like structure
- Event IDs

```
1 //blackbox/EventList.log
2 0x0000000000030386C;EL;BI;11
3 0x00000000000392811;EL;BO;3
4 0x00000000000E03C7;EL;DA;1
5 0x0000000000028A69A;EL;ER584;3
6 0x0000000000039791D;EL;LE;11
7 0x0000000000038A167;EL;LL;9
8 0x0000000000037DF96;EL;LS;11
9 0x00000000000390BEB;EL;LU;18
10 0x0000000000039699E;EL;OF;3
11 0x00000000000135A3A;EL;ON;2
12 0x0000000000038F1CF;EL;SC;122
13 0x0000000000038F1F4;EL;SS;106
14 0x00000000000281C83;EL;TB;9
15
16 //blackbox/ErrorEvents.log
17 0x000B3B04;ER;584;0;0;0;24;0;23;5;0;0;0;13608;20;0
18 0x000B9C8C;ER;584;0;0;0;24;0;23;5;0;0;0;13608;20;0
19 0x0028A69A;ER;584;0;0;0;22;0;23;5;0;0;0;13257;20;0
```

Forensic Artifacts – Events.log

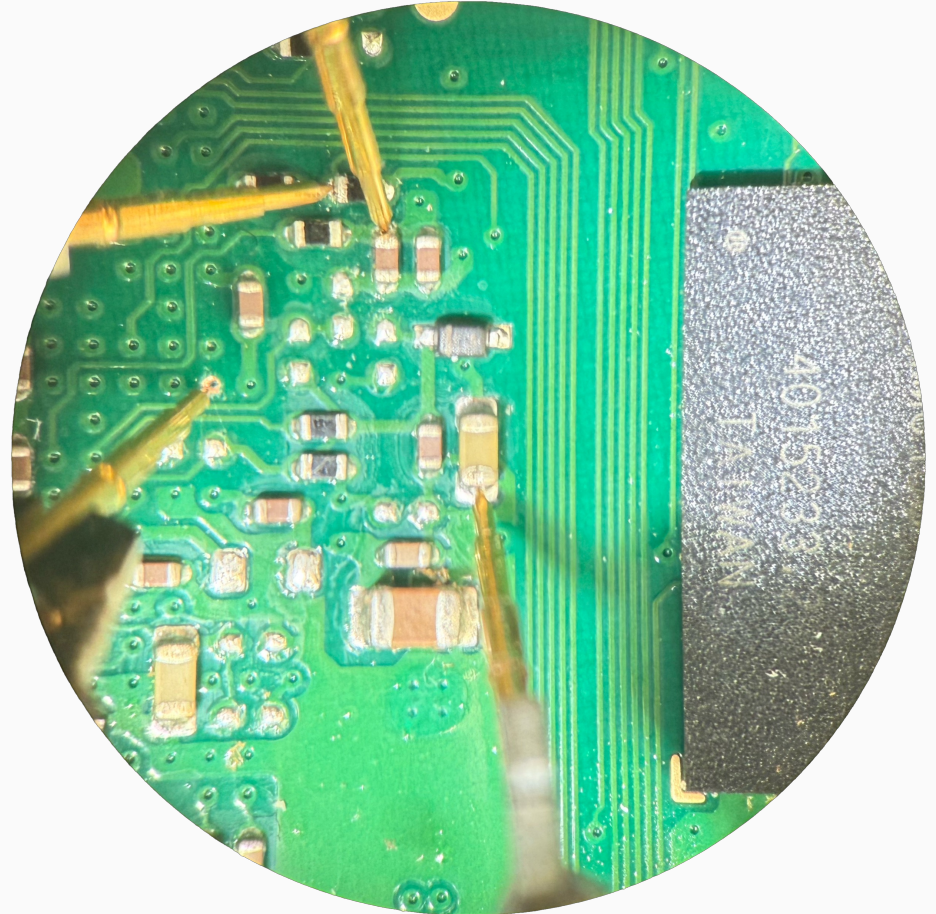
δ_{12}	Temperature	Clock	Speed	Dough Kneading	Pre-Clean Quick	Pre-Clean Dough
LS	ST 37	SC 1	SS 40	SS 600 S	SS 40 S	SS 40 S
ON 1747207908	ST 40	SC 2	SS 70	SS 0 S	SS 42 S	SS 42 S
SS 1	ST 45	SC 3	SS 350	SS 600 S	SS 44 S	SS 44 S
TB 0	ST 50	SC 6	SS 500	SS 0 S	SS 46 S	SS 46 S
BO 0	ST 55	SC 9	SS 800	SS 600 S	SS 48 S	SS 48 S
LU 1295	ST 60	SC 12	SS 1100	SS 0 S	SS 50 S	SS 50 S
TB 0	ST 65	SC 16	SS 1550	SS 600 S	SS 52 S	SS 52 S
BO -39	ST 70	SC 19	SS 2000	SS 0 S	SS 54 S	SS 54 S
LU 1295	ST 75	SC 22	SS 2550	SS 600 S	SS 56 S	SS 56 S
SS 1	ST 80	SC 26		SS 0 S	SS 58 S	SS 58 S
TB 0	ST 85	SC 30		SS 600 S	SS 60 S	SS 60 S
BO -39	ST 90	SC 34		SS 0 S	SS 62 S	SS 62 S
LU 1295	ST 85	SC 38		SS 0 S	SS 64 S	SS 64 S
SS 1	ST 80	SC 39		SS 1 S	SS 66 S	SS 66 S
OF Manual		SC 43		SS 600 S	SS 68 S	SS 68 S
LE		SC 47		SS 0 S	SS 70 S	SS 70 S
LS		SC 51		SS 600 S	SS 72 S	SS 72 S
SS 1		SC 54		SS 0 S	SS 74 S	SS 74 S
TB 0		SC 58		SS 600 S	SS 76 S	SS 76 S
BO 0		SC 70		SS 0 S	SS 78 S	SS 78 S
LU 1294		SC 110		SS 600 S	SS 80 S	SS 80 S
TB 0		SC 120		SS 0 S	ST 45 S	ST 37 S
BO -39		SC 150		SS 600 S	SS 0 S	SS 0 S
LU 1294		SC 180		SS 0 S	SS 1100 S	SS 800 S
SS 1		SC 220		SS 600 S	SS 0 S	SS 0 S
TB 0		SC 250		SS 0 S	SS 1100 S	SS 800 S
BO -39		SC 260		SS 0 S	SS 0 S	SS 0 S
LU 1294		SC 270		SS 1 S	SS 0 S	SS 0 S
SS 1		SC 300		SS 600 S	SS 1 S	SS 1 S
OF Manual				SS 0 S	SS 2000 S	SS 800 S
LE				SS 600 S	SS 0 S	SS 0 S

- Patterns visible
- Possible event IDs:
 - ON: power on
 - OF: power off
 - ST: set temperature
 - SC: set clock
 - SS: set speed

Data available at
github.com/mxchhrn/tm-blackbox

Factory Reset

- Incomplete data sanitization
 - `blackbox` log files
 - `Systemd` journal files
- Still extractable information
 - Recipes from Cookidoo
 - SSIDs of previous Wi-Fi connections
 - Usage information



Conclusion

Takeaway

- Forensically relevant artifacts can be obtained from TM6 devices
- Structural differential forensic analysis is necessary to identify data patterns
- Differential forensic analysis is useful to identify relevant files more systematically

Future Work

- More in-depth exploration of encrypted partitions
- Comparison with the successor TM7

Questions?

Maximilian Eichhorn

maximilian.eichhorn@fau.de

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Maximilian Eichhorn*, Felix Freiling

Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

ARTICLE INFO

Keywords:
digital forensics
kitchen appliance
IoT device forensics
smart home forensics
hardware forensics

ABSTRACT

To forensically examine an unknown digital device, a method is proposed that involves to perform experiments on an identical device and systematically derive information from the observed behaviour while performing specific actions. We apply this method to the Thermomix TM6 from Vorwerk, a multifunctional kitchen appliance. Using differential forensic analysis together with our method, we identify various forensic artefacts from real-world use, e.g., timestamps when the system was turned on and logs of specific cooking actions like dough kneading and cooking. We also observe inadequate data sanitization after factory reset. Other forensic artefacts we found include Wi-Fi login details and account information for the Cookidoo online service provided by Vorwerk to exchange recipes.