Smartphones are the key!

On the constraints of mobile computing in cloud avoidance

Rémy Raes
Spirals/WIDE research teams
Inria Lille

July 6th, 2026

Inria Université de Lille



Terminals



Services



Cloud



Privacy



Environment



Storage

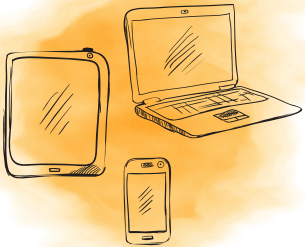
1. FLI

2. FLInD



Computing

3. INTACT



Terminals



Energy

6. Simply the Best



Communication

4. Survey

5. Venice



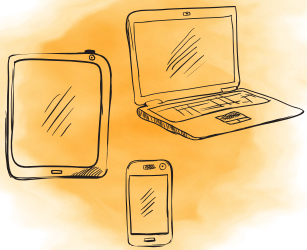
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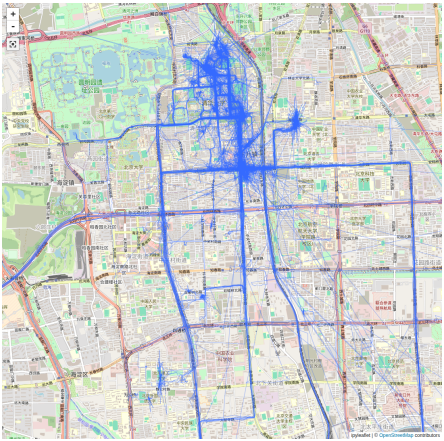
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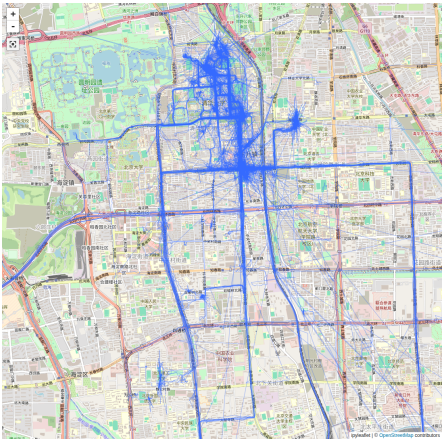
The location data case

- Location data is heavy (500MB/day)
- Location data is sensitive
- Can be mined to extract **Points of Interest** *(POIs)*
- Storage competitors exist: SQLite, SWAB, Greycat
  - But they're not satisfying



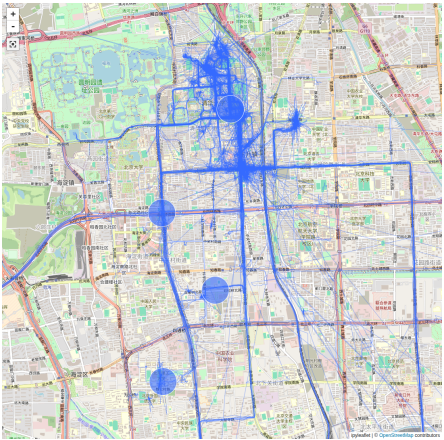
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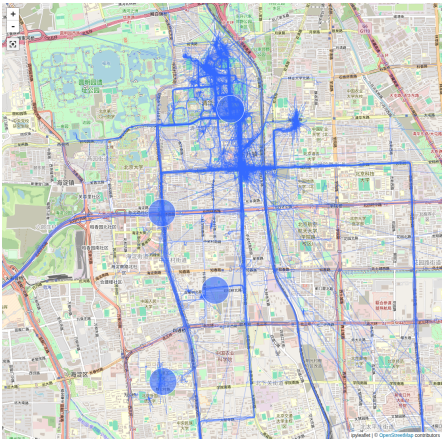
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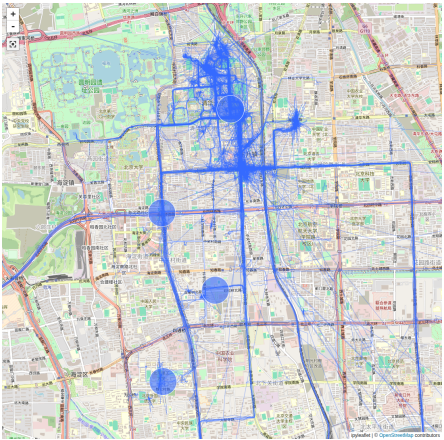
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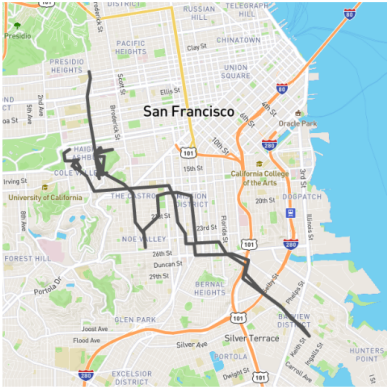


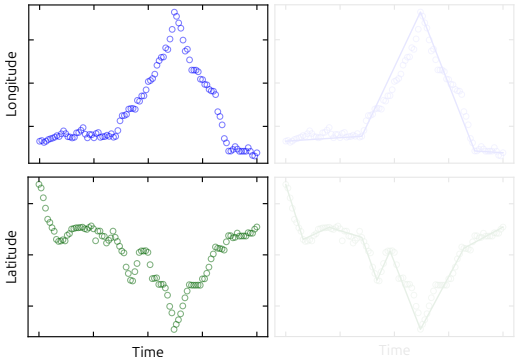
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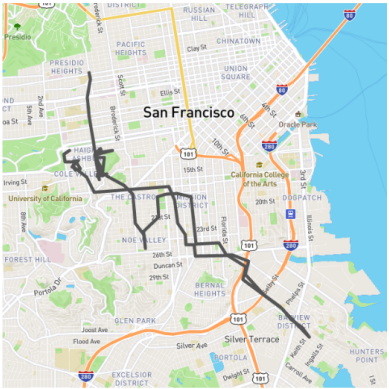
Our intuition





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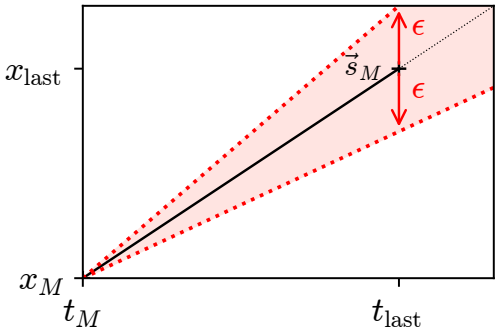
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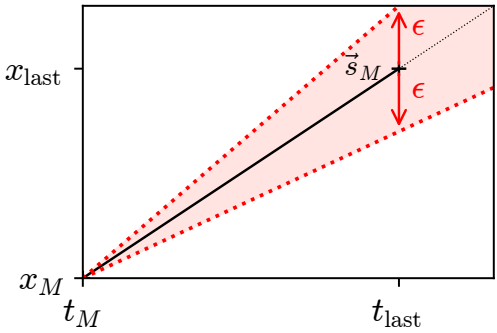
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- List of piecewise linear approximations
- Capture as many points as possible per linear segment
- Data approximation through error tolerance



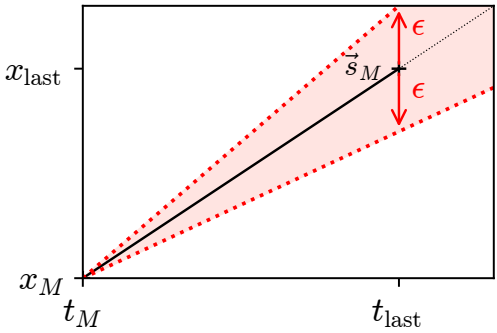
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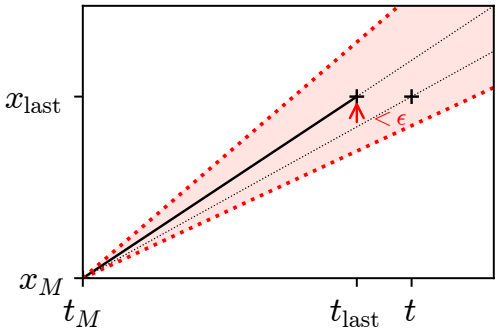
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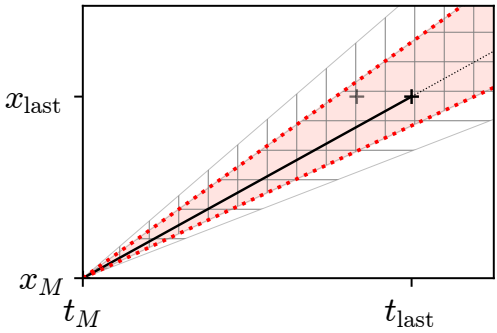
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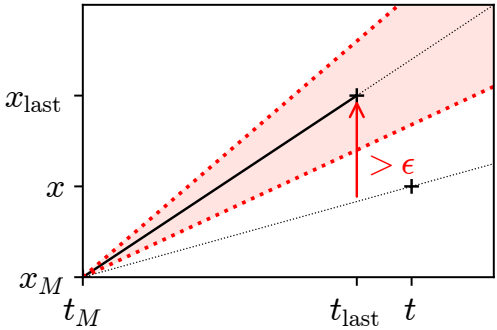
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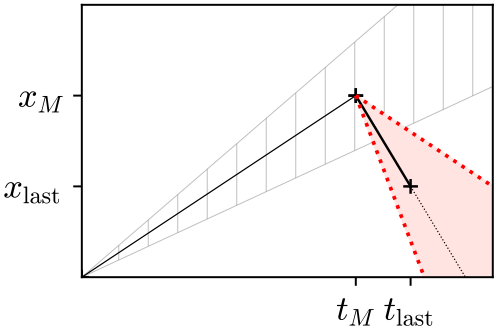
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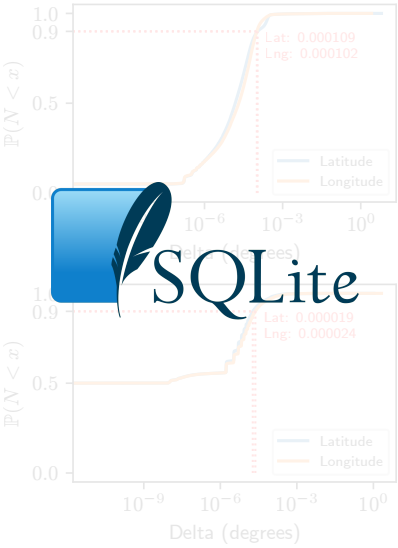
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  - SQLite
  - SWAB
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- Input data
  - Synthetic data
  - Accelerometer data
  - Cabspotting dataset (GPS, San Francisco)
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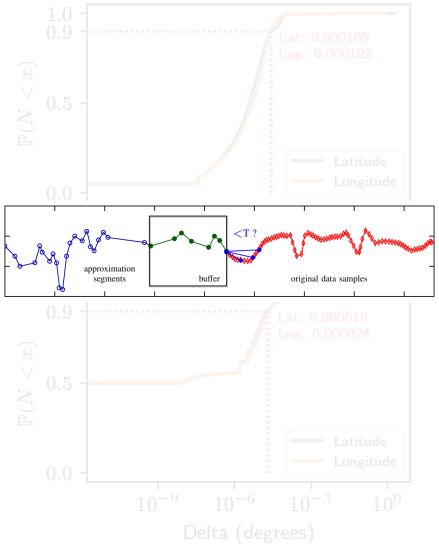
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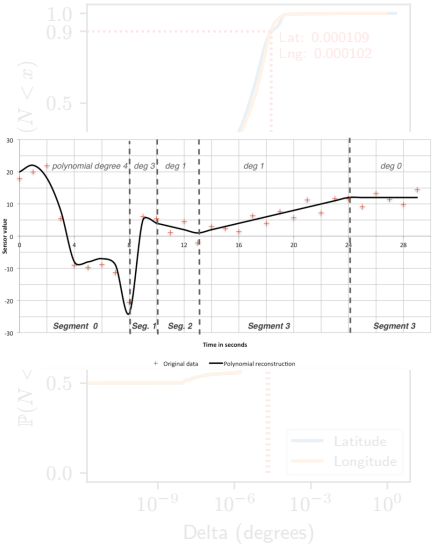
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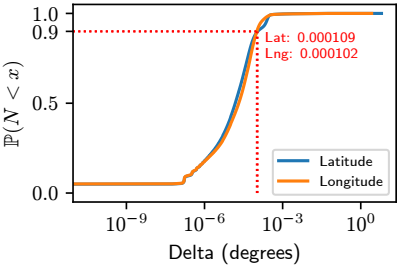


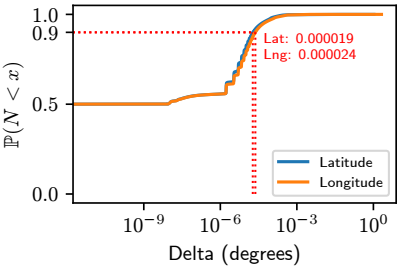
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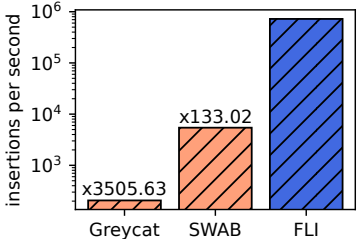
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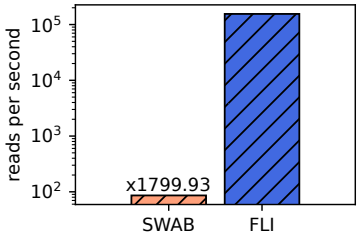




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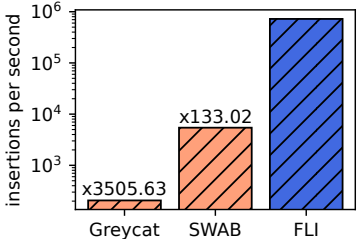
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- Substantial compression gains
  - CABSPOTTING: from **388MB** to **307MB** (-21%)
  - PRIVAMOV: from **7.2GB** to **25MB** (-99.65%)
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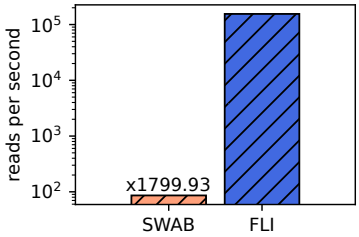




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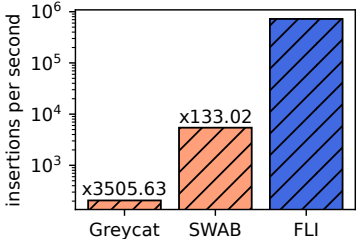
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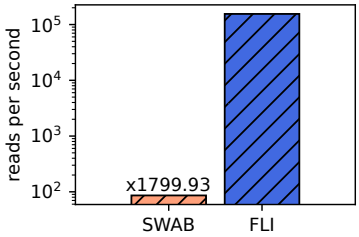




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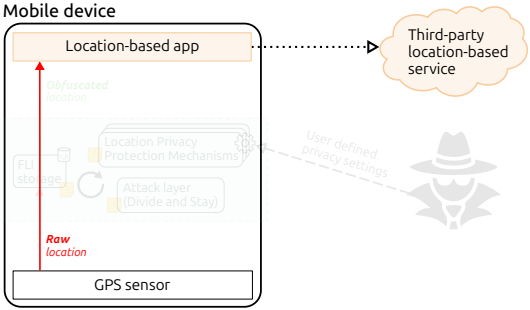
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Local privacy audit

- INTACT: *in situ* location protection

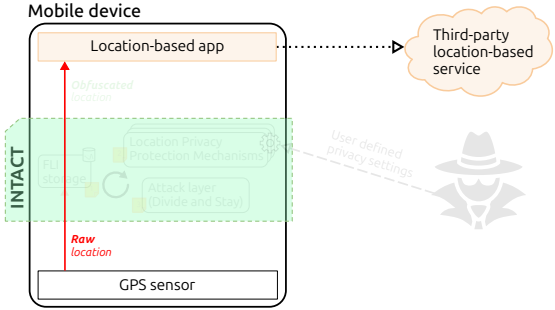


1. Local **storage** of private data
2. Local **protection** mechanisms
3. Local **attack** algorithms

- Locally **ensure data is safe** *before* sharing it

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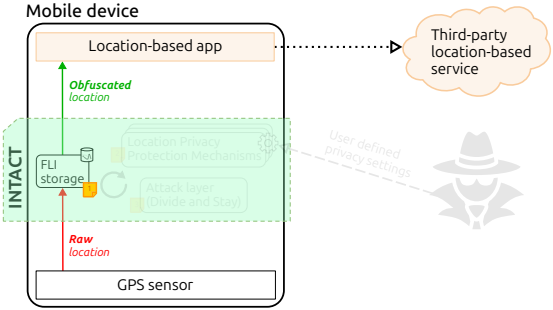


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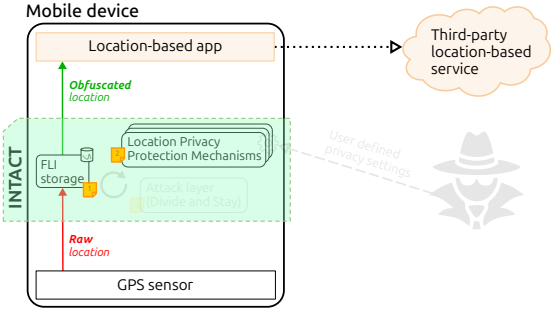


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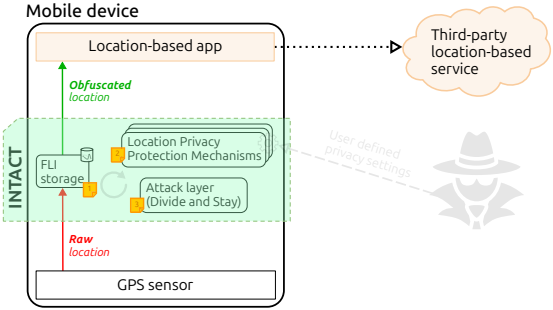


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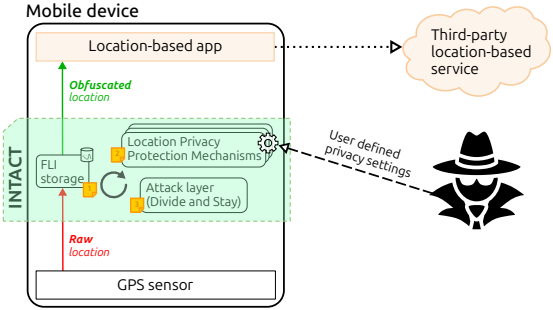


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- Implementation of the LPPM
- Execution time of a second

Figure: Toy example of the Promesse LPPM in action.

Attack: Divide&Stay

- POI-attack optimisation
- Execution time brought to the minute
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Figure: Distances distribution of modelled to closest raw POIs on Cabspotting.

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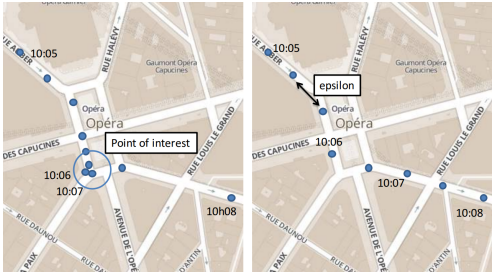


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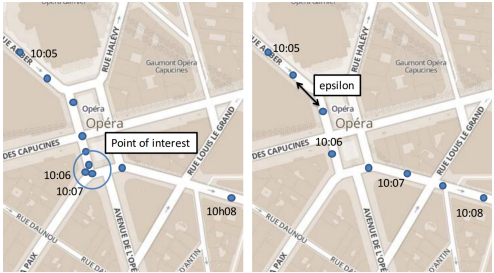


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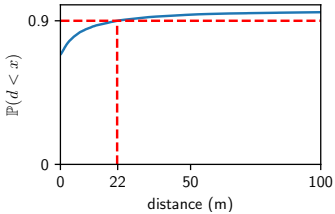


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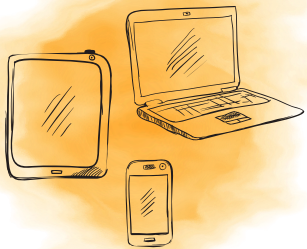
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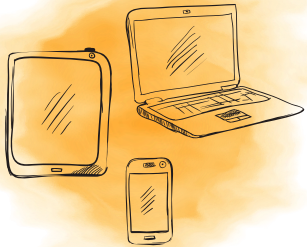
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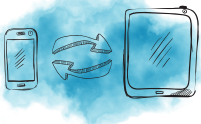
Storage
1. FLI
2. FLInD



Terminals



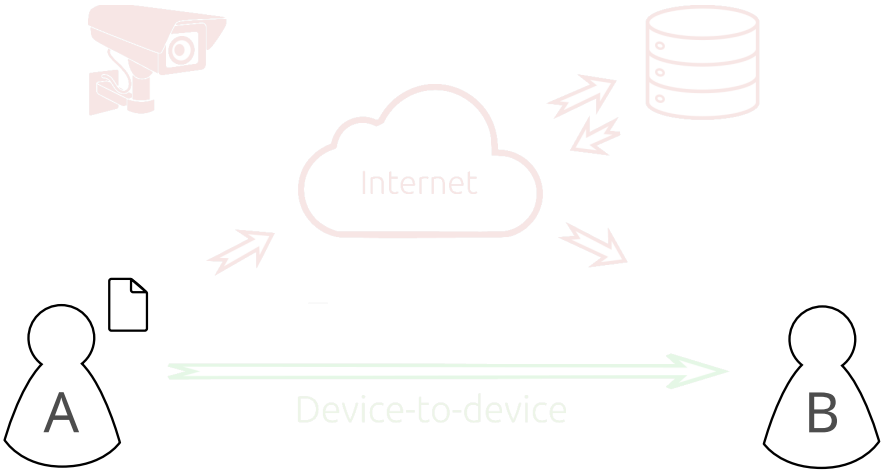
Computing
3. INTACT



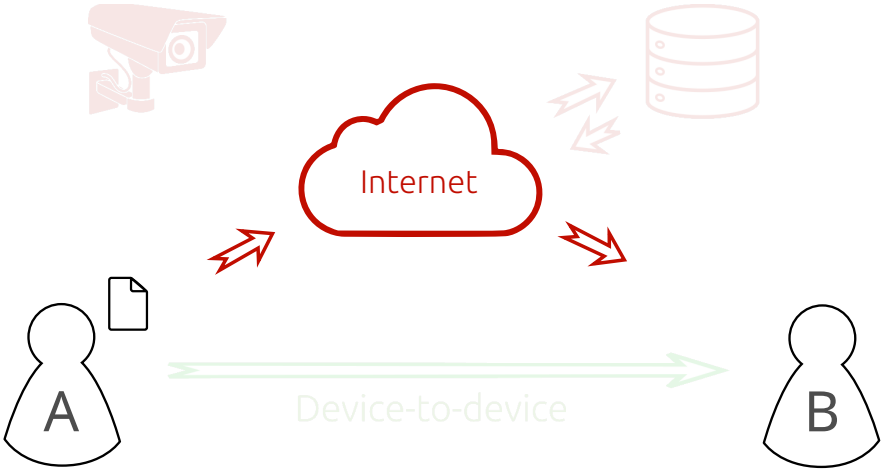
Communication
4. Survey
5. Venice

Energy
6. Simply the Best

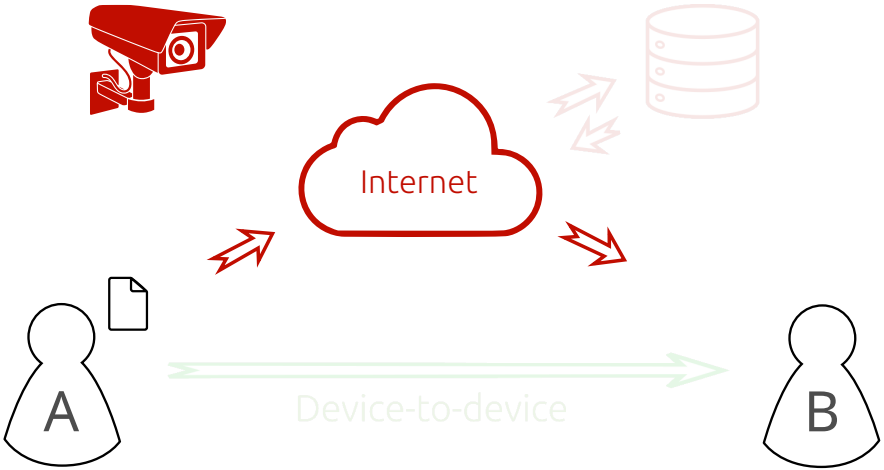
File exchange example



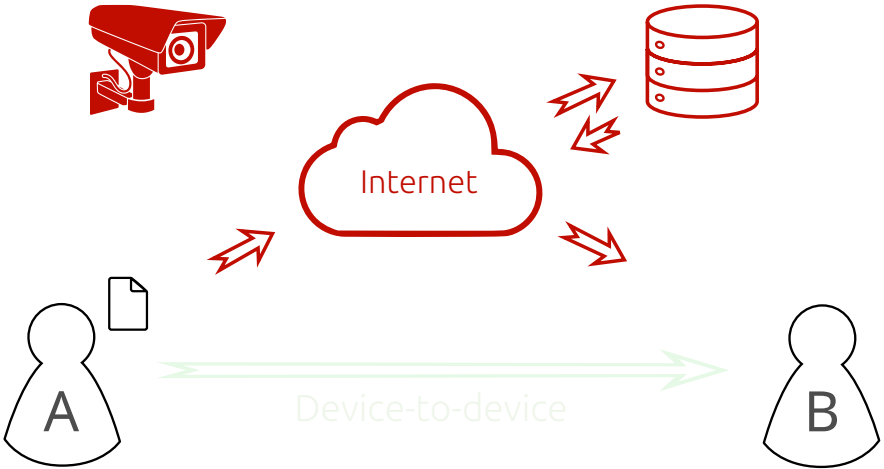
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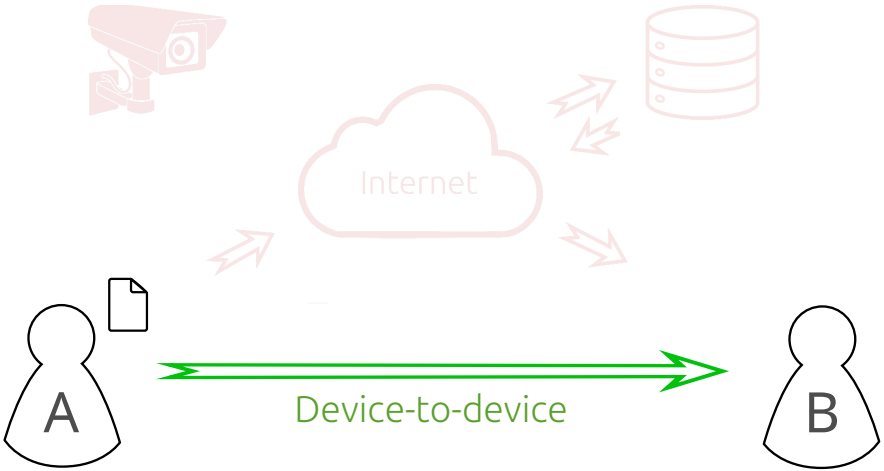
File exchange example



File exchange example



File exchange example



- Many technologies
- Widely deployed
- Proprietary frameworks
  - AirDrop
  - Quick Share

Name	Specification date	Maximum distance	Maximum data rate
Optical			
Infrared (IrDA)	1994	Several meters	16 Mb/s
QR code-flashing	—	Around a meter	23.6 kb/picture
Wi-Fi			
802.11 (legacy)	1997	100 m	1-2 Mb/s
802.11ax (Wi-Fi 6E)	2021	100 m	1.2 Gb/s
802.11ay	2021	10 m	100 Gb/s
Bluetooth			
Bluetooth Core v1	1999	100 m	1 Mb/s
Bluetooth Core v5	2016	100 m	1-3 Mb/s
RFID			
NFC	2004	20 cm	106-424 kb/s
Ultra-WideBand			
UWB	2007	200 m	27 Mb/s

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We realized a survey asking end users about their usage of communication technologies; it collected 364 answers.



Figure: Word cloud of received answers in the free-text feedback field.

Lauric Desauw, Adrien Luxey-Bitri, Rémy Raes, Romain Rouvoy, Olivier Ruas, et al. A critical review of mobile device-to-device communication. *DAIS 2025 - 25th International Conference on Distributed Applications and Interoperable Systems, Jun 2025, Lille, France.* **(hal-04198528v2)**

D2D survey: results

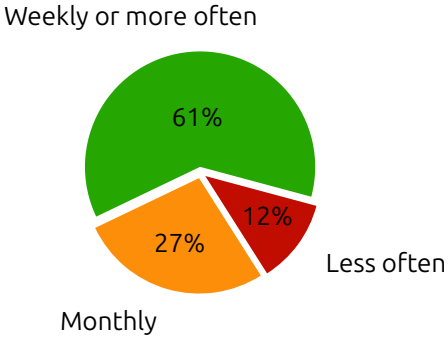


Figure: Distribution of the frequency of the need for D2D communication.

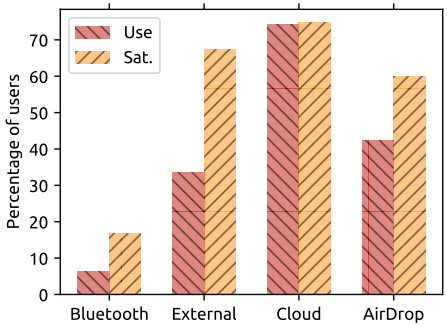
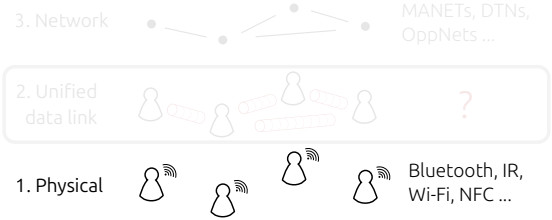


Figure: Use and satisfaction of the different available technologies.

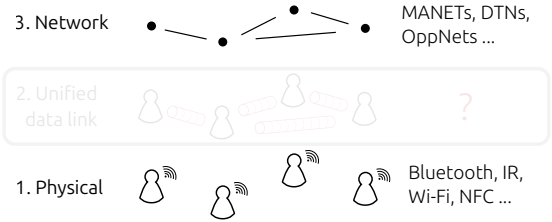
A missing communication layer

- Multiple technologies available
- Many use-cases
- Missing link in-between



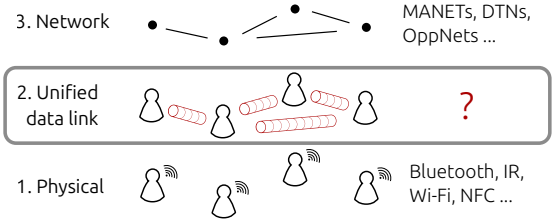
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- Multi-platform support (Android, iOS, Linux)
- Set of abstractions to support any tech implementation

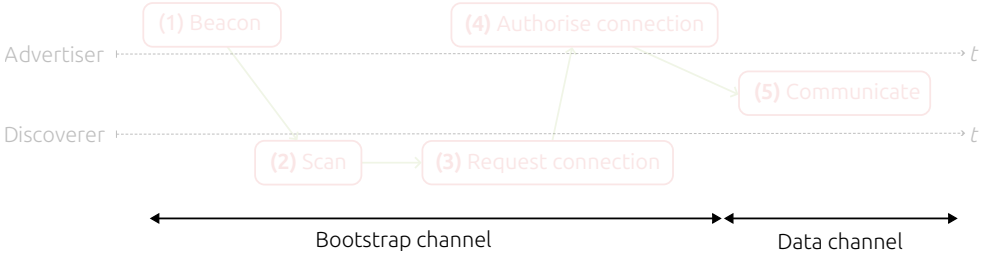
Rémy Raes, Adrien Luxey-Bitri, Romain Rouvoy, Davide Frey, François Taïani. Venice: eschewing the cloud by leveraging local communication channels. *ICT4S 2024 - International Conference on Information and Communications Technology for Sustainability, Jun 2024, Stockholm, Sweden.* **(hal-04576743)**

A framework proposal: Venice

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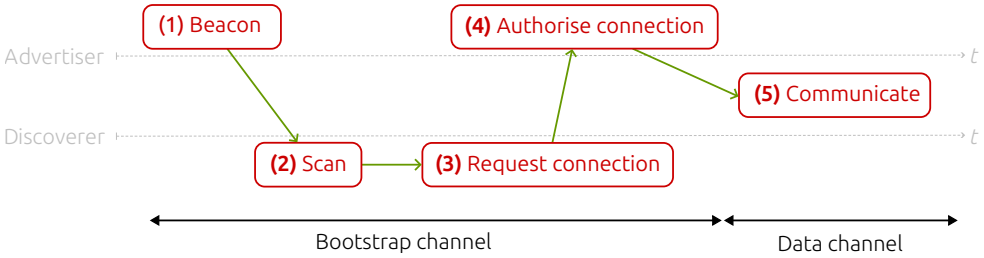
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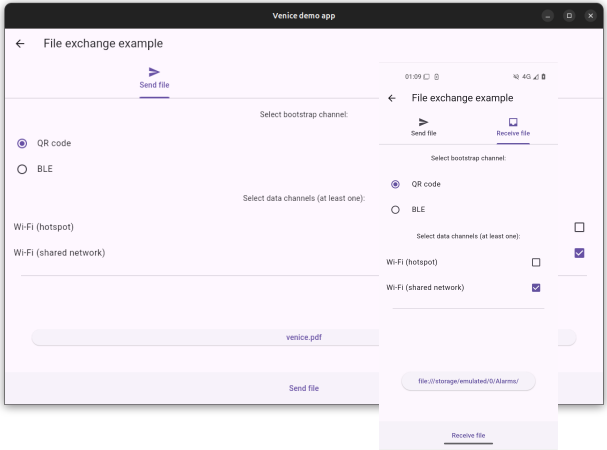
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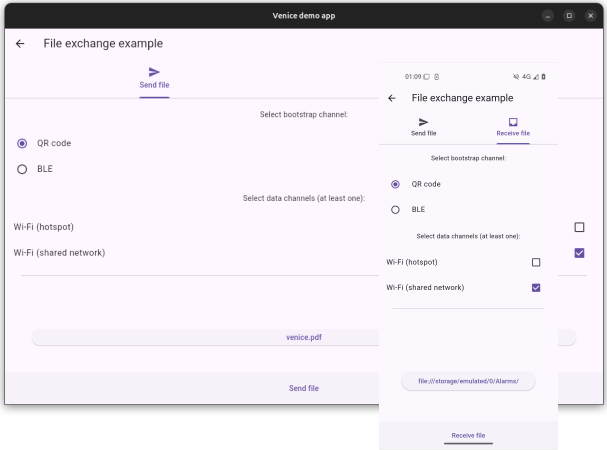


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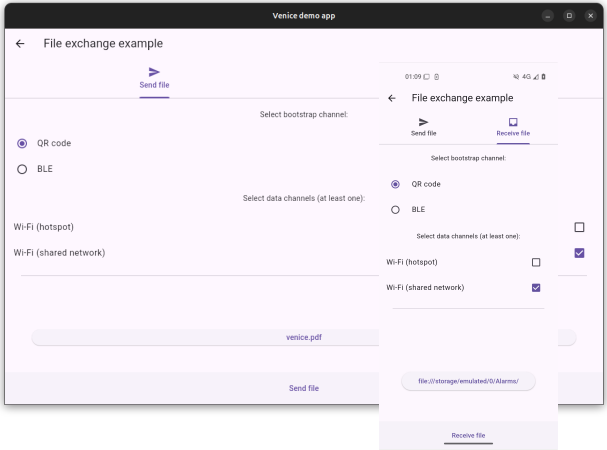
- Demo application
- Manual choice of channels
- Several use-cases:
  - Text copy-pasting
  - File exchange
  - Video streaming



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- Uneven system API support
- Tedious integration process
- Creating a multi-platform framework requires multi-platform knowledge
- Missing high-level API

PeripheralManager

API	Android	iOS	macOS	Windows	Linux
state	✅	✅	✅	✅	
stateChanged	✅	✅	✅	✅	
authorize	✅				
showAppSettings	✅	✅			
connectionStateChanged	✅				
mtuChanged	✅			✅	

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```
@override
Future<void> initReceiver() async {
    ConnectionData? connectionData;
    await centralManager.setUp();

    // Wait for Bluetooth to be ready
    while (await centralManager.getState() != BluetoothLowEnergyState.poweredOn) {
      debugPrint("Waiting for Bluetooth to be ready...");
      await Future.delayed(const Duration(milliseconds: 500));
    }

    // Start listening to devices
    centralManager.discovered.listen((event) async {
        String? advName = event.advertisement.name;
        if (advName != "venice") {
          return;
        }

        // Explore device only if it's Venice compatible
        await centralManager.stopDiscovery();
        await centralManager.connect(event.peripheral);

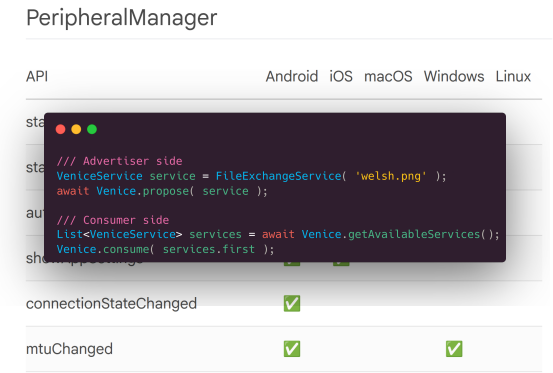
        // Retrieve data channel data from the correct service/characteristic
        List<GattService> services = await centralManager.discoverGATT(event.peripheral);
        List<GattService> matchingServices =
            services.where((element) => element.uuid == veniceUuid).toList();

        GattCharacteristic distantChannelCharacteristic =
                matchingServices.first.characteristics
                    .firstWhere((element) => element.uuid == veniceChannelCharacteristicUuid,
                    orElse: () => throw RangeError("Channel characteristic not found."));

        Uint8List cValue = channelNullValue;
        do {
          cValue = await centralManager.readCharacteristic(distantChannelCharacteristic);
          await Future.delayed(const Duration(seconds: 1));
        } while (cValue.toString() == channelNullValue.toString() || cValue.isEmpty);

        ChannelMetadata channelMetadata = ChannelMetadata( utf8.decode(cValue).split(";") );
        // Data channel can now be opened...
    }
}
```

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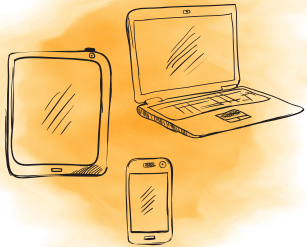




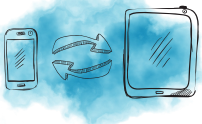
Storage
1. FLI
2. FLInD



Computing
3. INTACT



Terminals



Communication
4. Survey
5. Venice

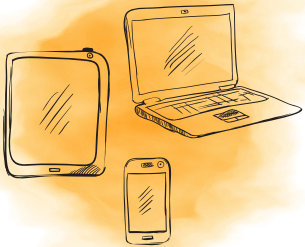
Energy
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Storage
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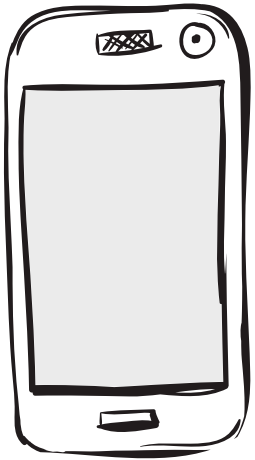


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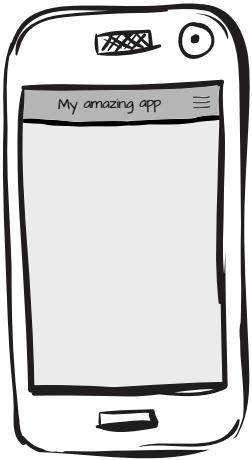


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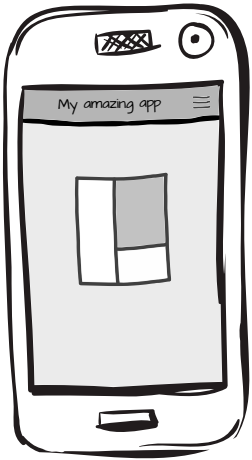
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- Many TPLs for the same feature...
- ...and biased ways to pick one



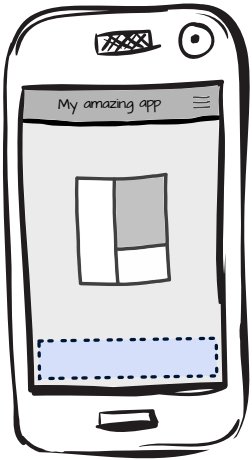
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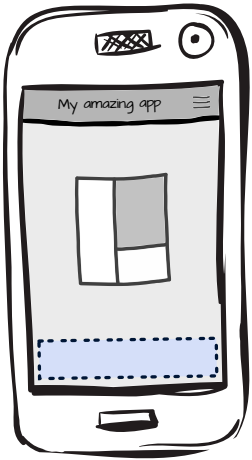
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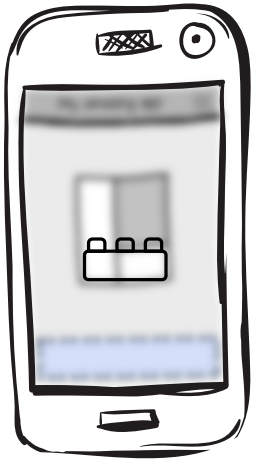
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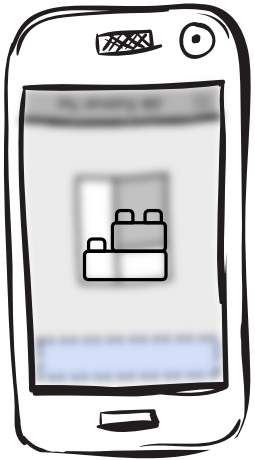
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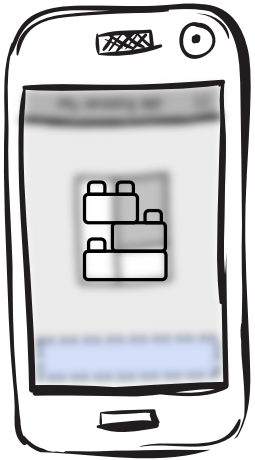
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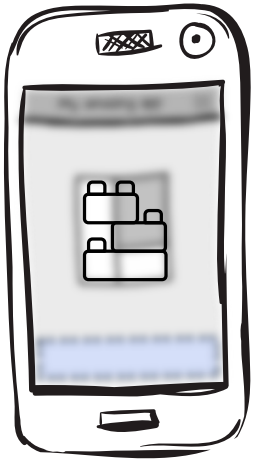
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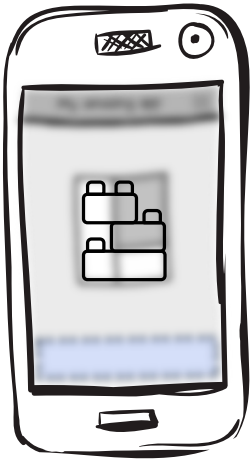
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Android Ad Network statistics and market share

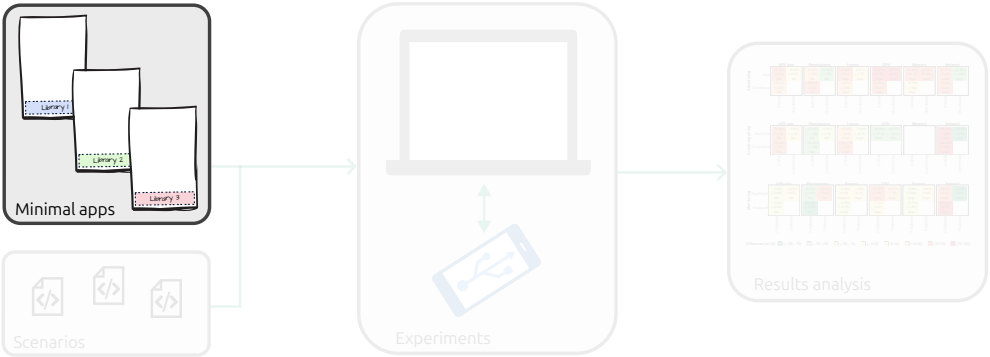
Use the market share of Android Ad networks below to find the best and most popular Ad networks.
More information about these statistics

Ad networks | Social libraries | Development tools

Sort by: Installs, Apps Market share in: Overall, New, Top 500

AdMob	AdMob	AdMob is one of the world's largest mobile advertising networks, offering solutions for discovery, ...	40.97% of apps 33.55% of installs
iab. TECH LAB	Open Measurement	The IAB Open Measurement SDK (OM SDK) offers common code and libraries for facilitating third-party...	9.55% of apps 18.56% of installs
facebook	Facebook Audience Network	Facebook Audience Network allows you to monetize your Android apps with Facebook ads.	12.38% of apps 16.86% of installs

Rubén Saborido, Rémy Raes, Rodrigo Morales, Romain Rouvoy, Foutse Khomh & Yann-Gaël Guéhéneuc. Simply the best – A systematic evaluation approach for third-party libraries based on mobile app quality attributes. *Empirical Software Engineering 31, 137 (2026).* **(10.1007/s10664-026-10872-w)**

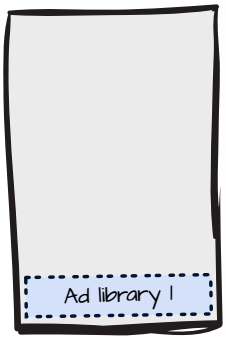


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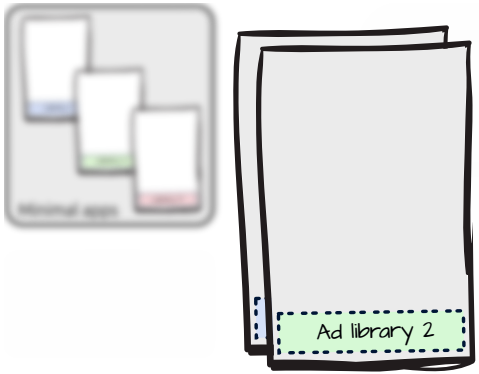


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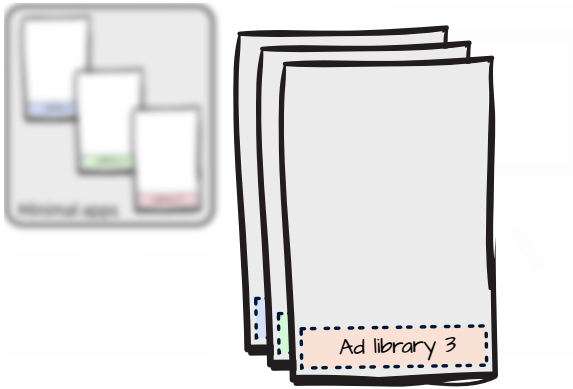




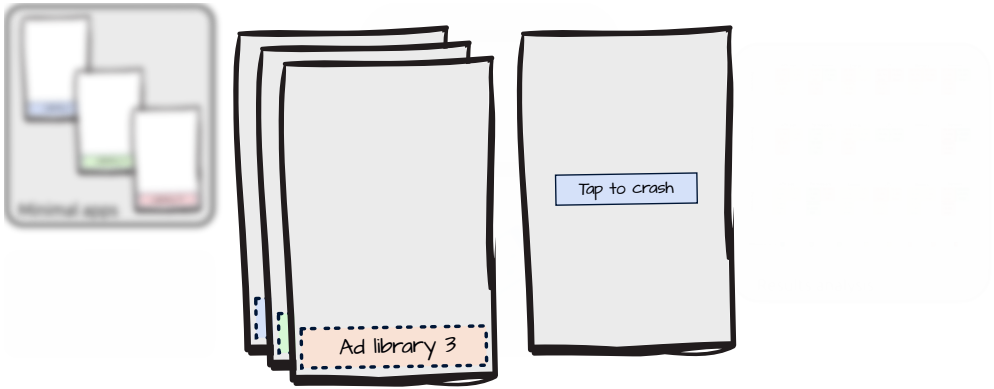
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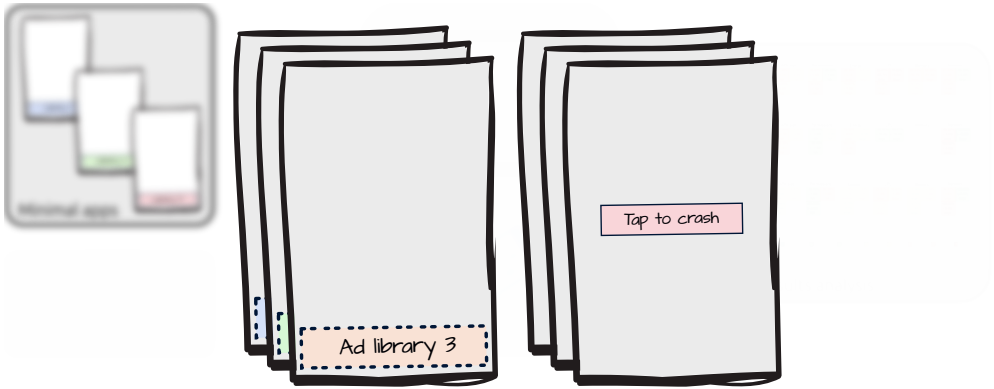
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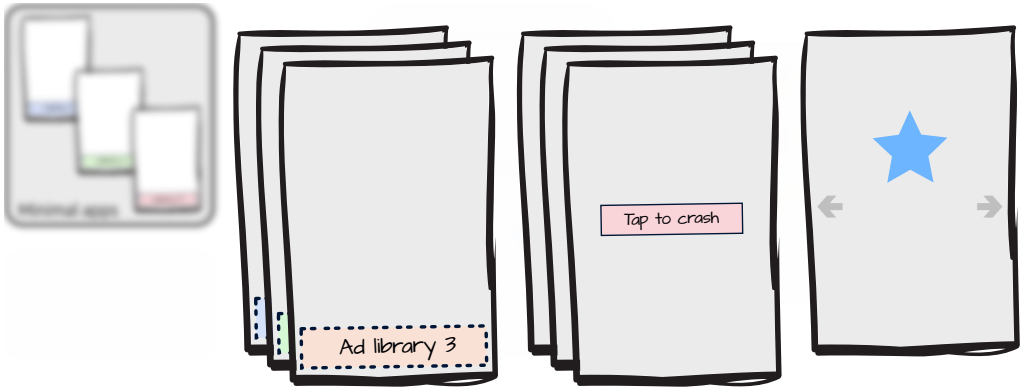
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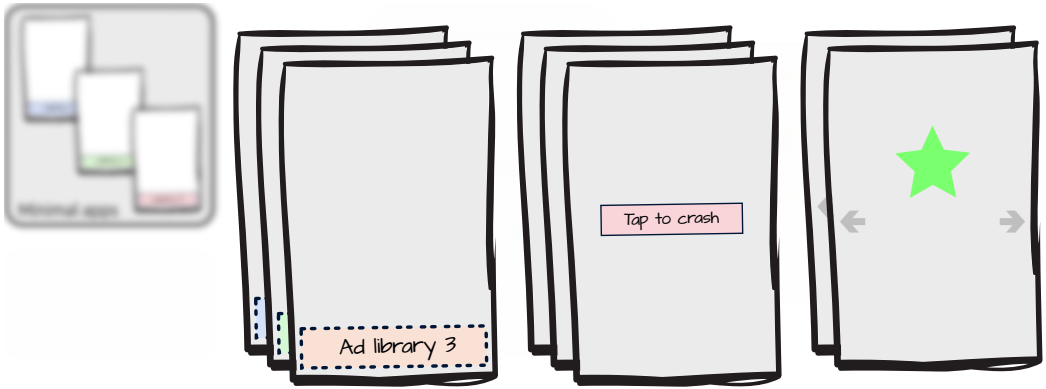
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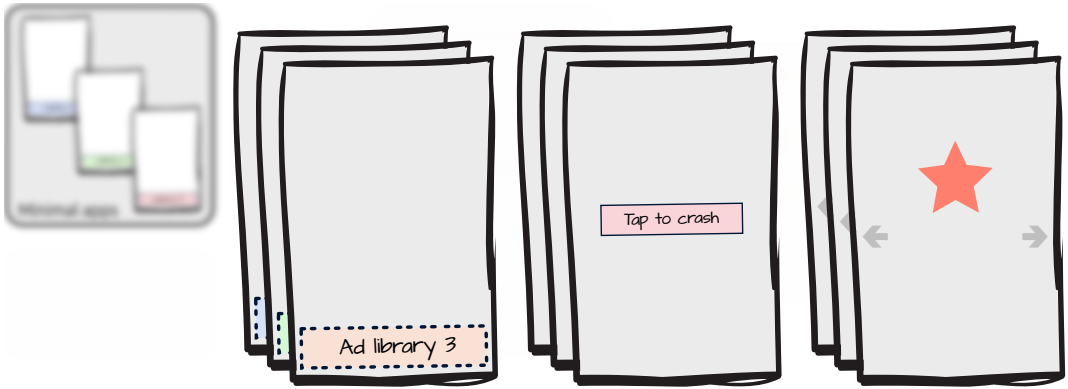
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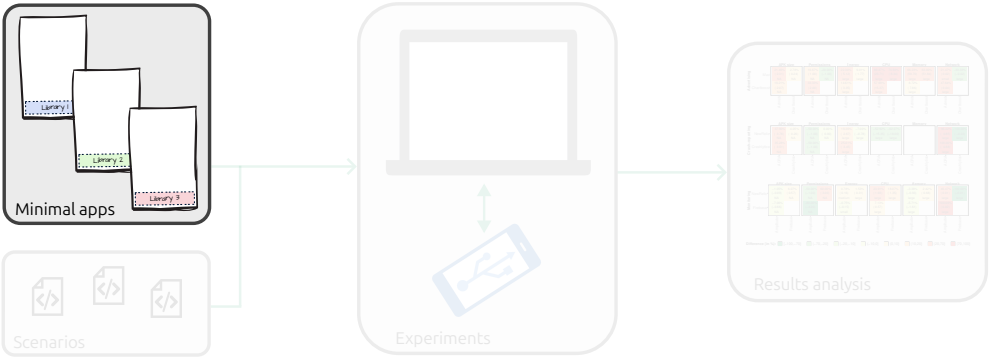
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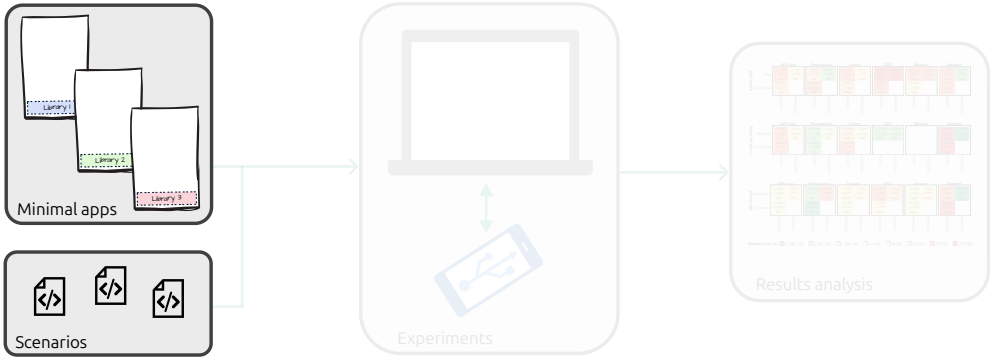
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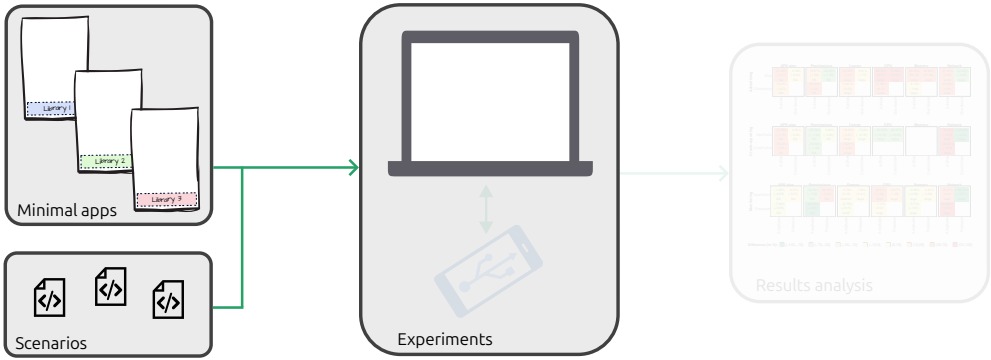
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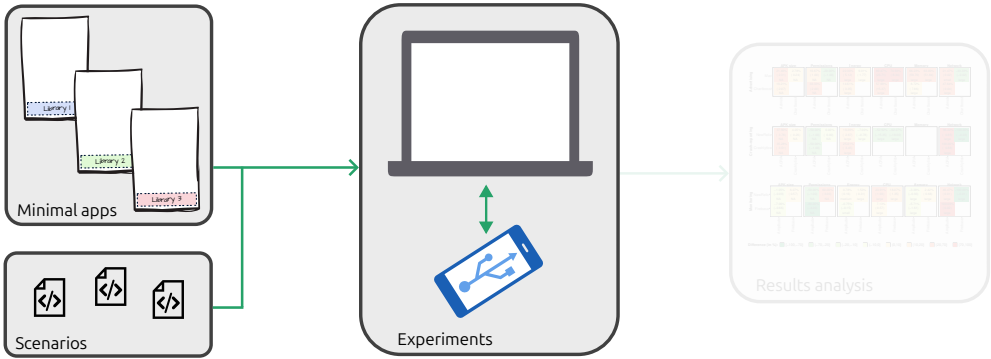
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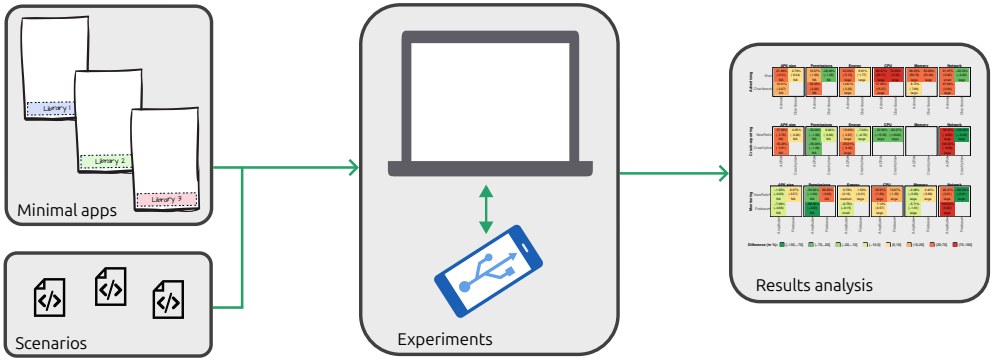
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Table: Popular Android TPLs for popular TPL categories.

Name	Version	Provider	Category
Admob	20.5.0	Google	Advertising
Chartboost	9.1.0	Chartboost	Advertising
Max	11.5.3	AppLovin	Advertising
ACRA	5.9.7	ACRA	Crash-reporting
Crashlytics	29.0.4	Google	Crash-reporting
NewRelic	6.4.1	New Relic	Crash-reporting
Amplitude	2.23.2	Amplitude	Monitoring
Firebase	29.0.4	Google	Monitoring
NewRelic	6.4.1	New Relic	Monitoring

- App size
- Energy
- Memory
- Permissions
- CPU
- Network

Figure: Android library energy test bench.

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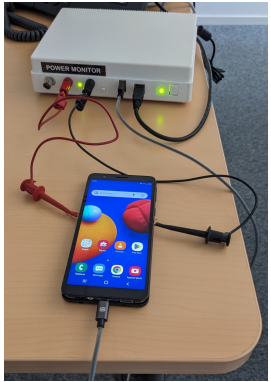
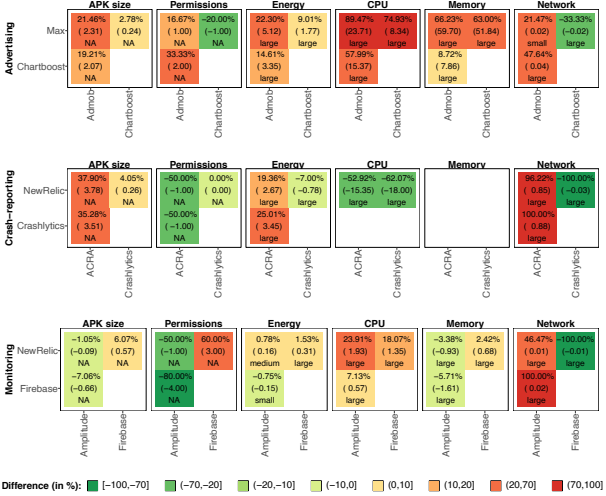
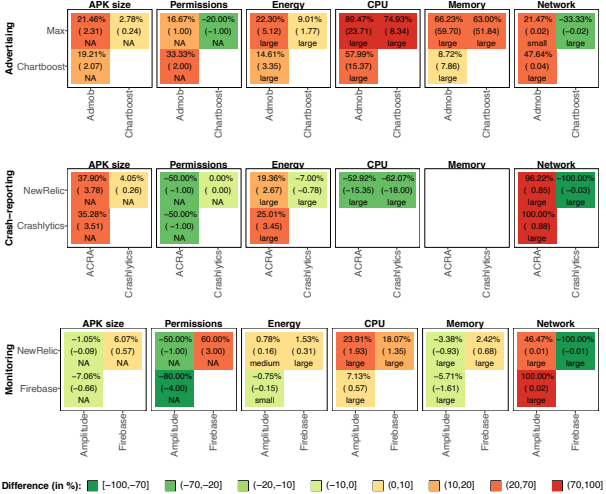


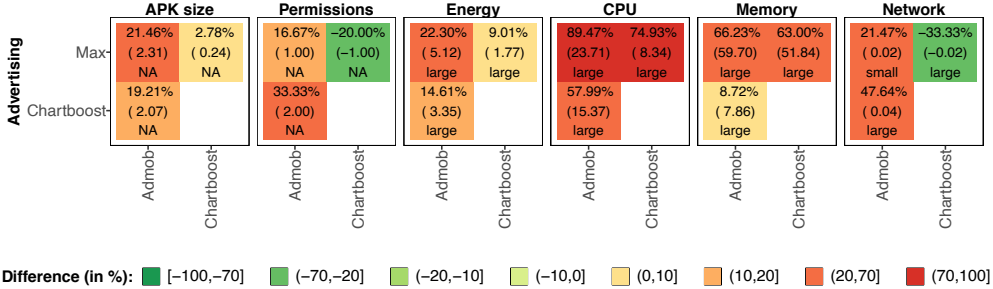
Figure: Android library energy test bench.

- Dashboard as output
- Global overview of libraries

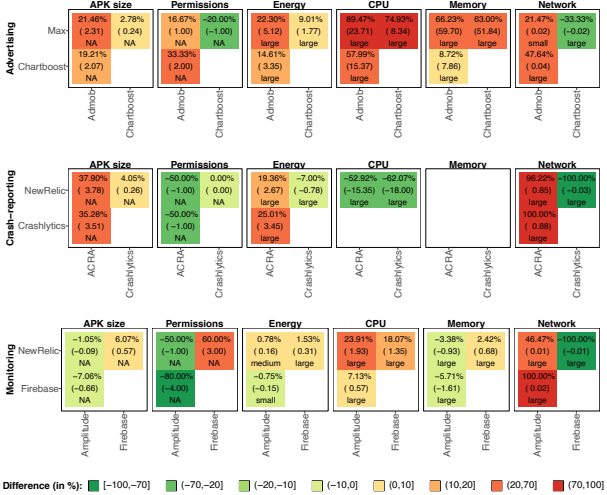


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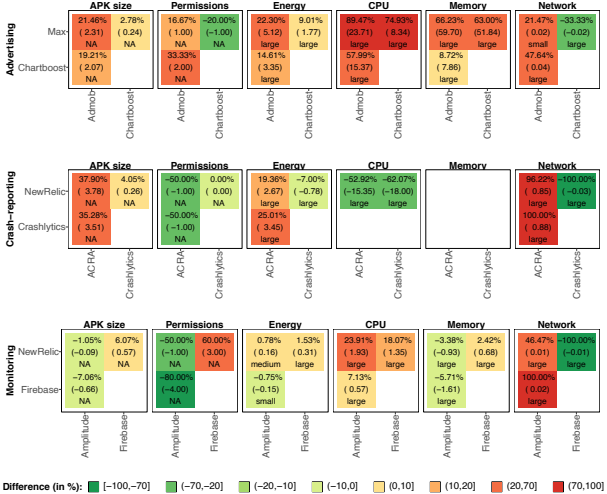



APK size
Permissions
Energy
CPU
Memory
Network
Advertising
Max
Chartboost
21.46% (2.31) NA
2.78% (0.24) NA
19.21% (2.07) NA
16.67% (1.00) NA
−20.00% (−1.00) NA
33.33% (2.00) NA
22.30% (5.12) large
9.01% (1.77) large
14.61% (3.35) large
89.47% (23.71) large
74.93% (8.34) large
57.99% (15.37) large
66.23% (59.70) large
63.00% (51.84) large
8.72% (7.86) large
21.47% (0.02) small
−33.33% (−0.02) large
47.64% (0.04) large
Admob
Chartboost
Difference (in %):
[−100,−70]
(−70,−20]
(−20,−10]
(−10,0]
(0,10]
(10,20]
(20,70]
(70,100]

- No clear winner... as expected!
- Multiple libraries, for multiple use-cases



- No clear winner... as expected!
- Multiple libraries, for multiple use-cases

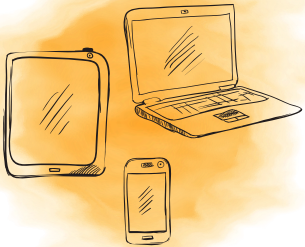




Storage
1. FLI
2. FLInD



Computing
3. INTACT



Terminals



Energy
6. Simply the Best



Communication
4. Survey
5. Venice



Storage

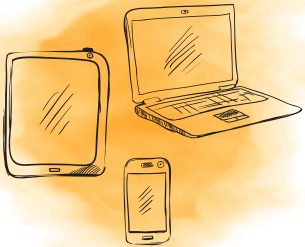
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