Differentiating Cache Files for Fine-grain Management to Improve Mobile Performance and Lifetime

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Executive summary

Problem: Unnecessary writebacks of cache files negatively impact performance and lifetime

Most cache files in flash storage will not be read again before they are deleted

Cache files are different at application-level, file-level, and read pattern-level

Improve the performance and lifetime of mobile devices

Key idea

FCFM: Fine-grain cache file management framework

A: Burn-After-Reading (BAR)

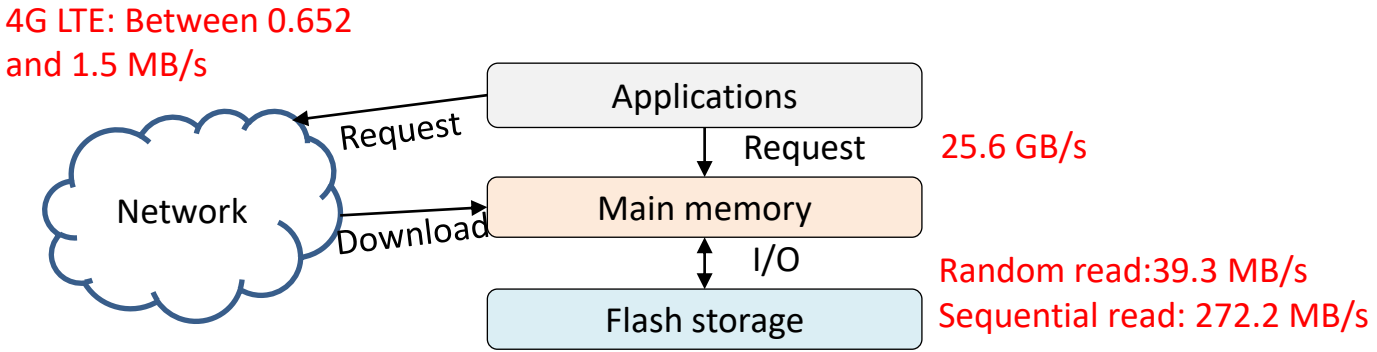
B: Transient

C: Long-living

Total writes of cache files into flash storage in FCFM is 66% and
93% less than that of the fully-in-memory and fully-in-storage, respectively.

Mobile apps usually downloads cache files

- Most mobile apps download cache files from network, such as news and videos.



How do these cache files affect mobile devices?

Cache files impact performance and lifetime

- Cache files, such as news and videos
  - Writes of cache files -> degrade performance
  - Write and delete of cache files -> reduce lifetime

5 Ways to Speed Up Your Android Phone in Under 5 Minutes

By Sean Riley April 27, 2017 Android

If your Android phone has slowed down over time, you can make it run faster by following just a few quick tips. Here's how to do it.

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(Image credit: LDProd/Shutterstock.com)

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MORE: Android Guide: Tips, Tricks and How-Tos for Nougat and Marshmallow

Clear your Cached Data (30 seconds)

6 Everyday Tips to Speed Up Your Computer — Get A Faster PC!

Do you find yourself booting up your computer each day, only to wait endless minutes for it to get up and running? Worse still, do you launch programs and constantly deal with them freezing or crashing? These aren't just annoyances — they're signs from your PC, telling you it's time to speed up your system. And, if you're like many, you might be wondering how to speed up your computer Windows, 7, 8 and 10 operating systems.

The good news is that there are many subtle things that you can do to simply speed up your operating system. Taking the time to do these 6 simple tasks will help in speeding up computer programs, preventing crashes and keeping your entire PC running smoothly:

1. Clear caches

How to speed up your iPhone by clearing your cache?

By Matthieu Andre 2019-03-13 1545 0

Get a bunch of Applications on your iPhone? Documents stack on your device may cause a poor performance and even lead to a frozen screen. Because you leak data on Websites or Applications, your system will automatically update before you log-in and have access. Regards to your storage capacity, major internal improvements by Apple will optimize your device by clearing your cache and erasing data. Efficient and powerful, if you want your iPhone run faster, here are few tips.

GC

Garbage collection of flash storage copying + erasing

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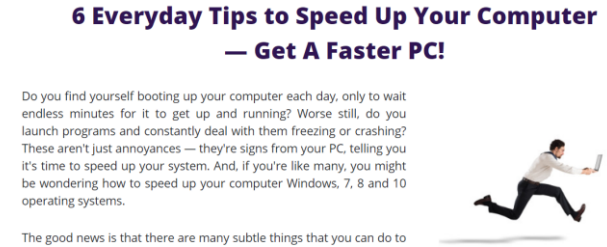
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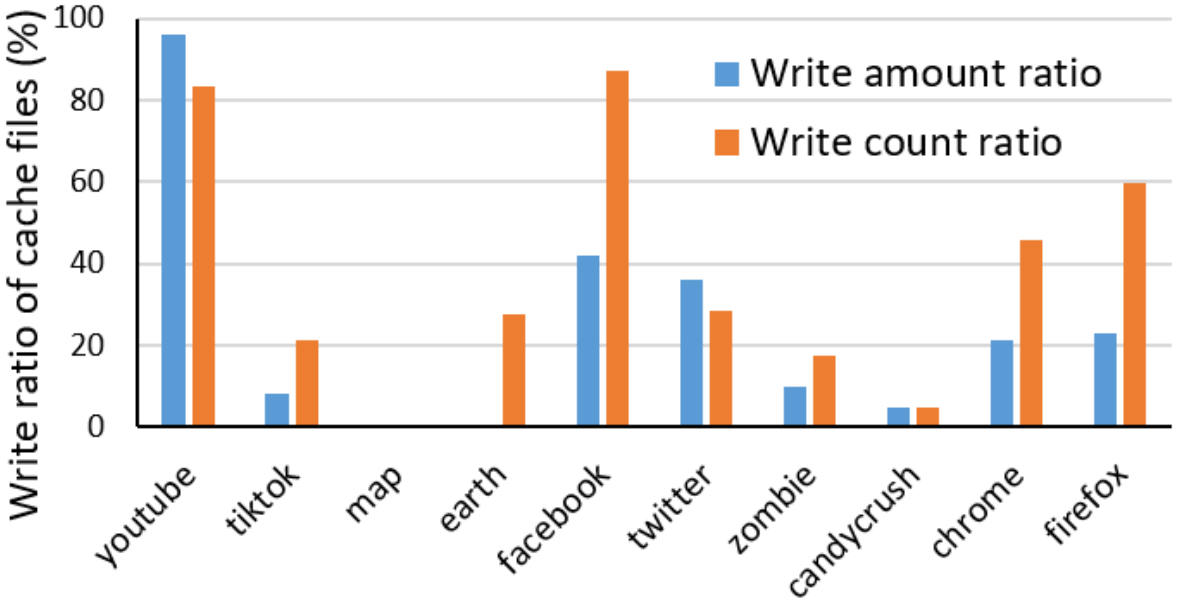
Garbage collection of flash storage

What is the proportion of cache file writebacks in total I/O?

Cache Files are Important for Mobile Apps

- The percentage of cache file writebacks in total I/O.



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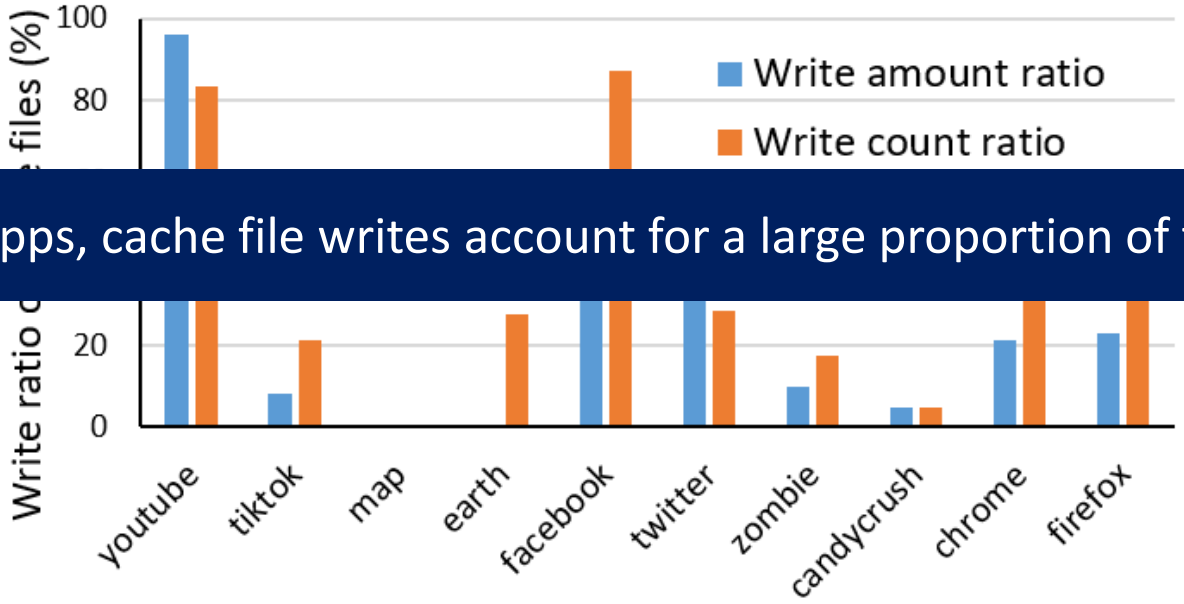

For some apps, cache file writes account for a large proportion of total writes.

Cache File Analysis

- Experimental setup
  - Huawei P9 smartphone equipped with an ARM Cortex-A72 CPU, 32GB internal flash memory and 3GB RAM. The smartphone runs Android 7.0 with Linux kernel version 4.1.18.

Type	Apps	Workloads
Social media	Facebook	View news: (a) drag the screen to load news; (b) load the news for displaying; (c) repeat (a) and (b).
	Twitter	
Map	Map	Search address: (a) type key words; (b) load the news for displaying; (c) drag the screen, zoom in and zoom out the map; (d) repeat (a) (b) and (c).
	Earth	Scan satellite maps: (a) drag the screen, zoom in and zoom out the map; (b) repeat (a).
Game	CandyCrush	Load and play CandyCrush.
	Zombie	Load and play Plants vs. Zombies.
Video	Youtube	Play series: (a) type key words; (b) load the news for displaying; (c) auto-play long series.
	TikTok	Play videos: (a) drag the screen to load news; (b) play short video; (c) repeat (a) and (b).
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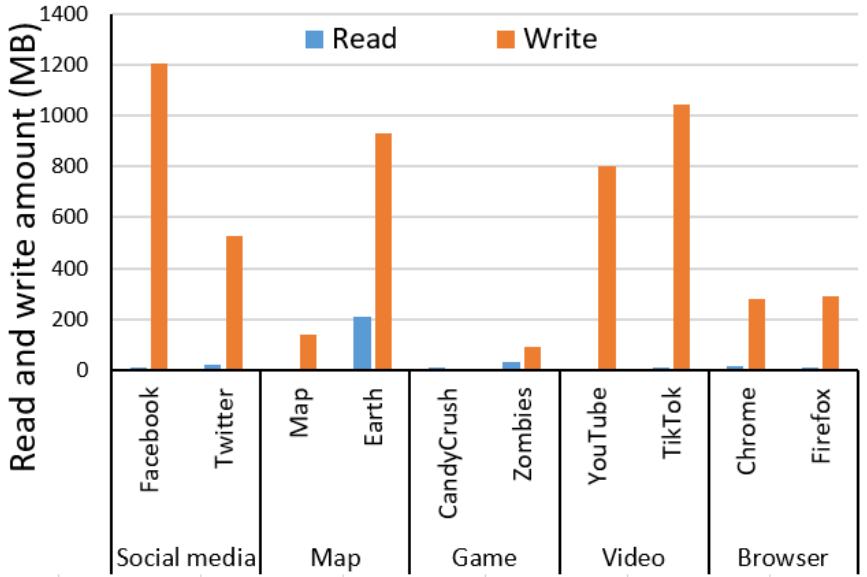
We analyze cache files under one of common scenarios.

Cache File Analysis at Application-level

- Read and write amount of cache files in flash storage



- **Observation 1**: Cache file accesses of apps vary in terms of data amount.
- **Observation 2**: On average, write amount is 100X more than read amount.

Cache File Analysis at Application-level

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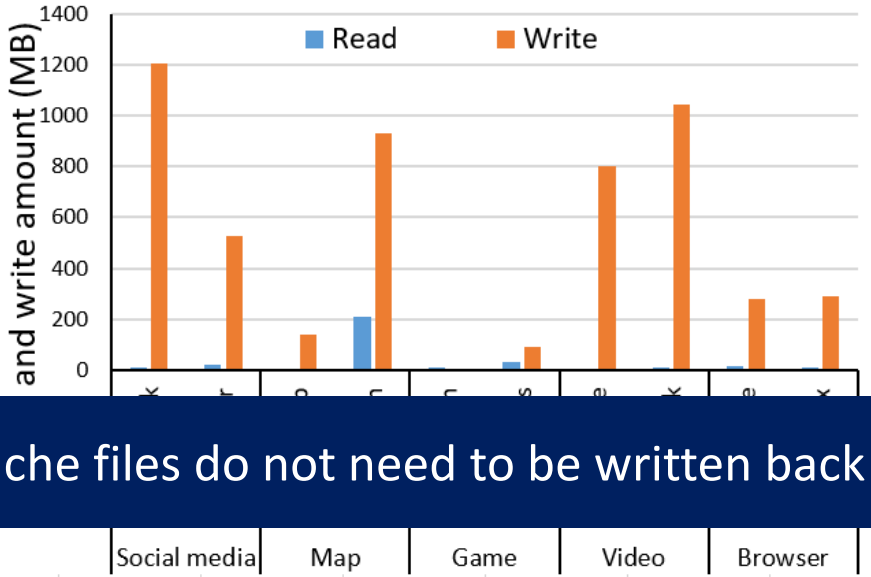

Most of cache files do not need to be written back to flash storage.

- **Observation 1**: Cache file accesses of apps vary in terms of data amount.
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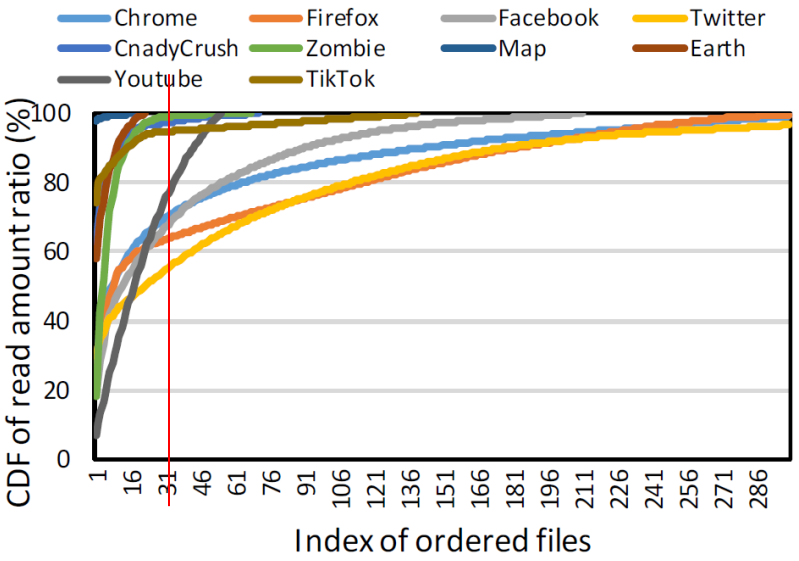
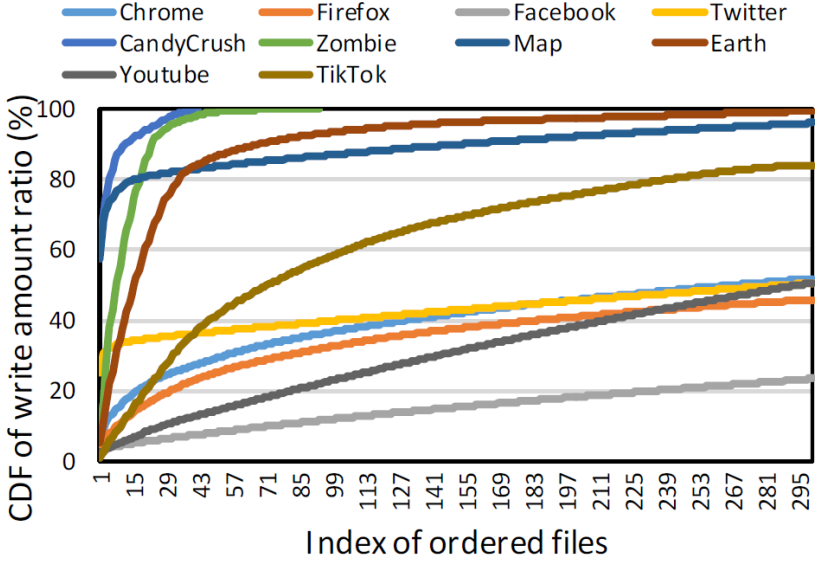
Cache File Analysis at File-level

- CDF of read/write amount ratio of cache files.



CDF of **read** amount ratio of cache files.



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Cache File Analysis at File-level

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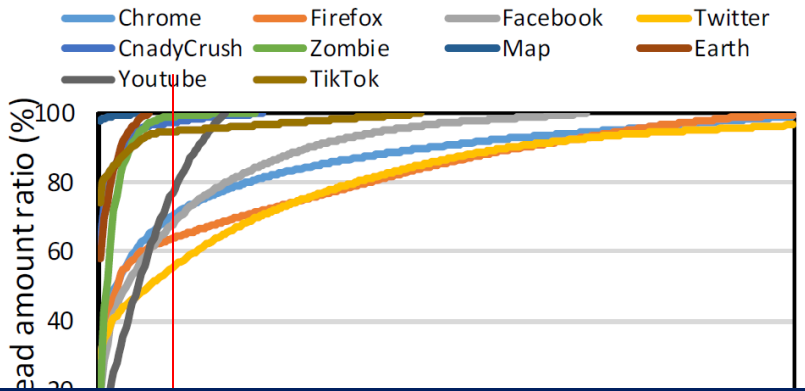

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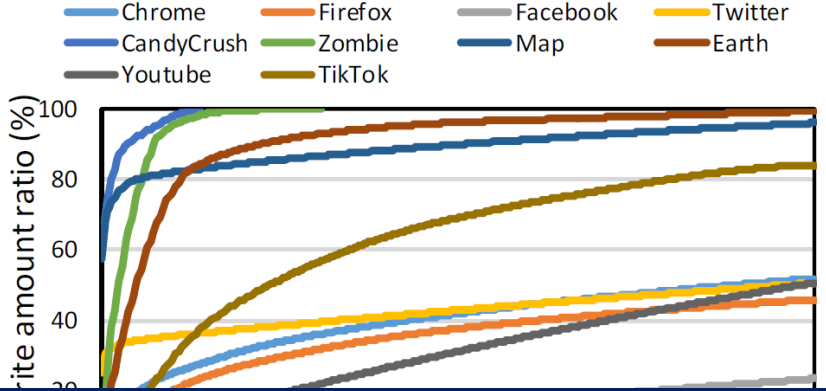


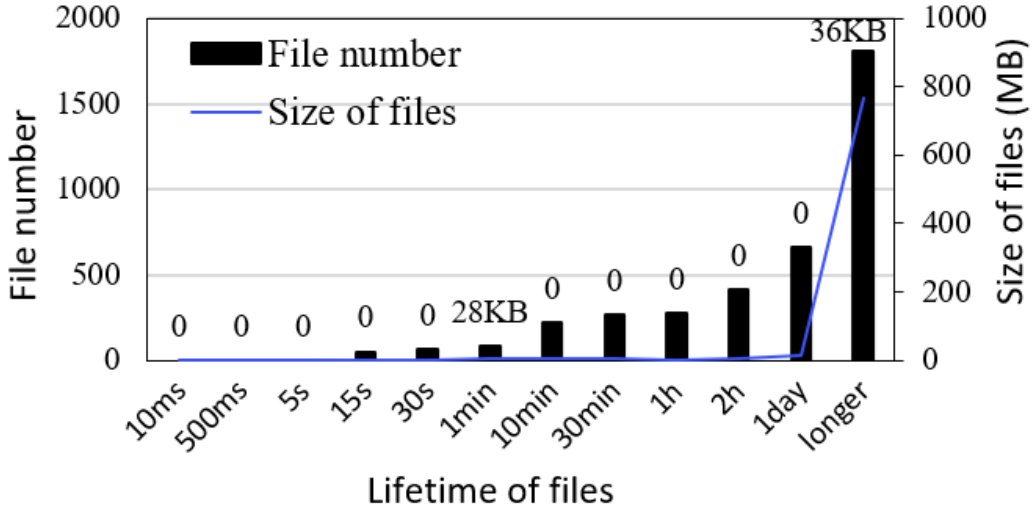
CDF of **write** amount ratio of cache files.

Only storing this small set of cache files may improve the user experience.

- **Observation 3**: Most of the read amounts of the applications are concentrated on few cache files.

Cache File Analysis at File-level

- Cache file features of applications

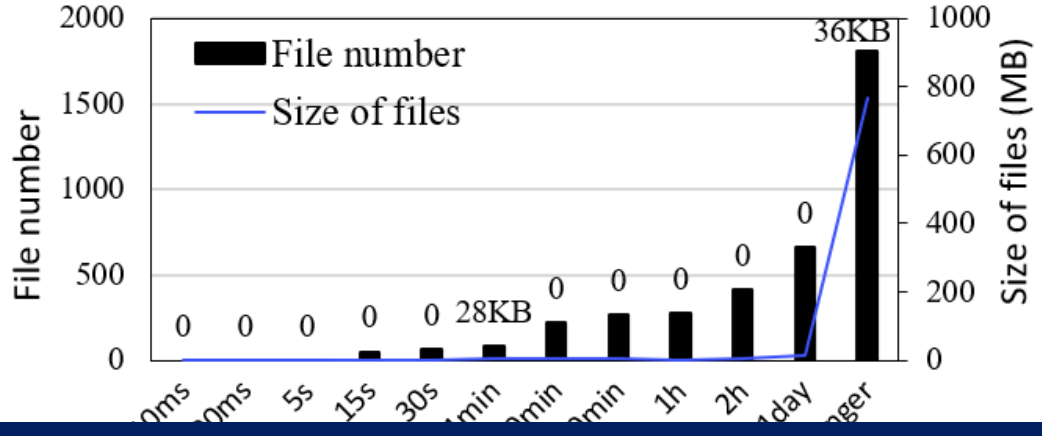


Cache file features of YouTube

- **Observation 4**: Most of the reads are conducted on long-lifetime cache files.
- The size of these files is more than 50% of the total size of all cache files.

Cache File Analysis at File-level

- Cache file features of applications



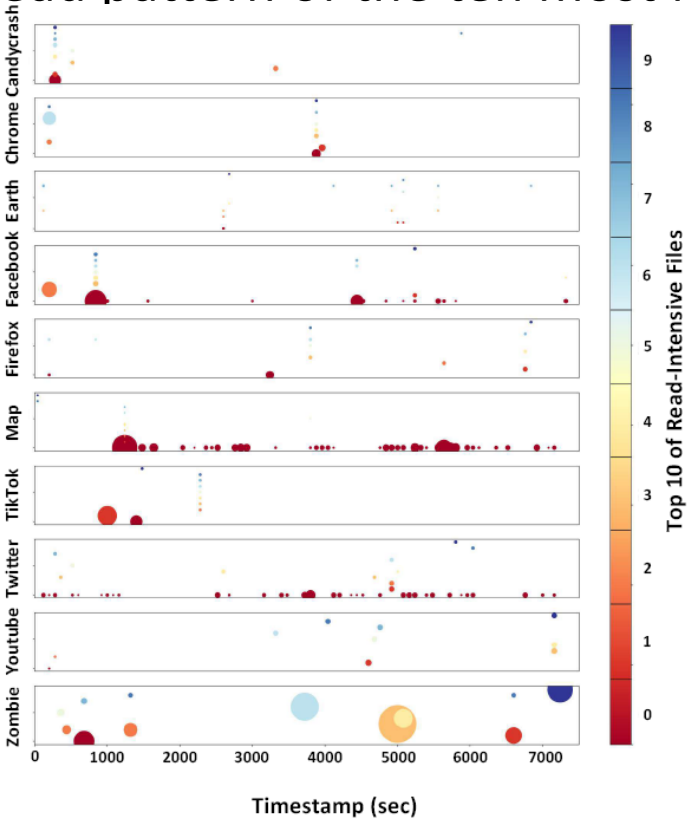
Discarding the short-lifetime cache may halve the writes.

Cache file features of YouTube

- **Observation 4**: Most of the reads are conducted on long-lifetime cache files.
- The size of these files is more than 50% of the total size of all cache files.

Cache File Analysis at Read Pattern-level

- Read pattern of the ten most read cache files for each application.



Observation 5: From the temporal perspective, two types of read patterns:

1) Concentrated reads in a short time period ;
2) Reads across the application execution time.

Cache File Analysis at Read Pattern-level

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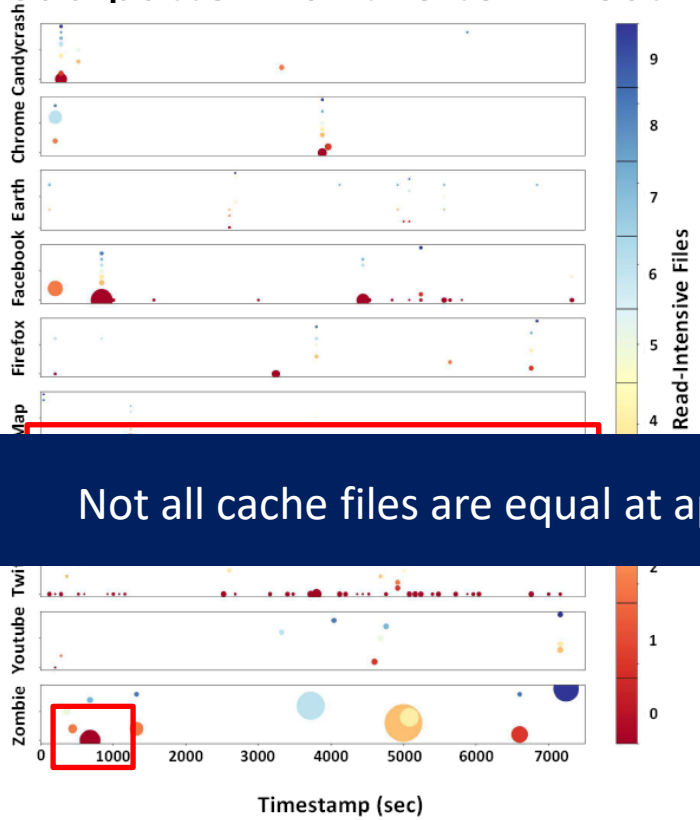

Observation 5: From the temporal perspective, two types of read patterns:

1) Concentrated reads in a short time period ;
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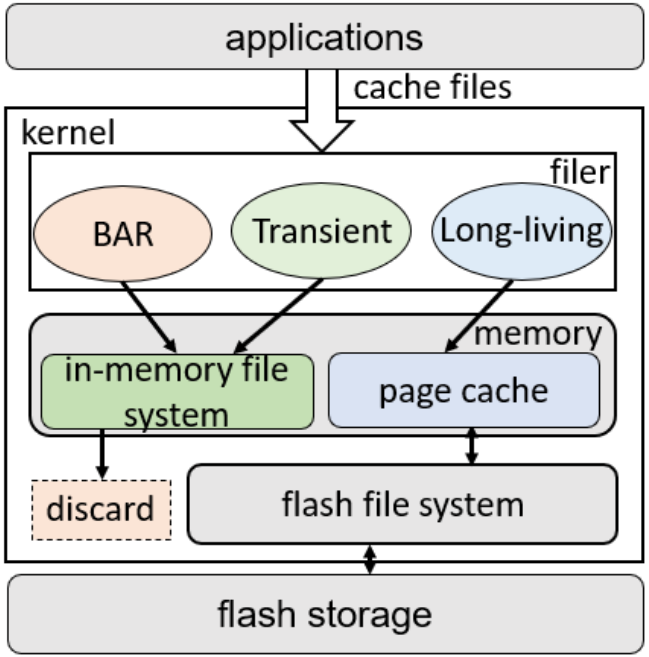
Not all cache files are equal at application level, file level, and pattern level.

Fine-grain cache file management (FCFM)

- FCFM manages different cache files according to their characteristics.



Framework of FCFM

➢ **Three classes:**

- **Burn-After-Reading (BAR):** large write amount but a tiny read amount.
- **Transient:** large write amount and a large read amount as well as a short active period.
- **Long-living:** large read amount and long active period.

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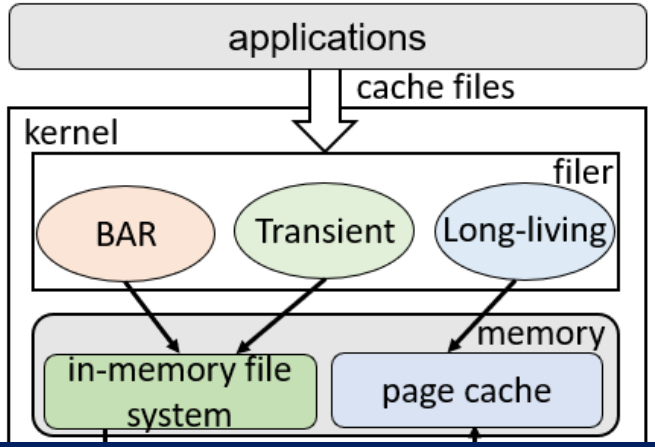

Framework of FCFM

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Treat different cache files separately.

Preliminary evaluation and analysis

- Preliminary evaluation results: video cache of YouTube

Categories	Write amount	Write numbers	Cache/exo read
Baseline (in flash)	345MB	5000	60KB from flash
In memory	71MB	5757	60KB from memory
FCFM	24MB	1736	60KB from network

FCFM can improve the performance and lifetime of mobile devices.

- Penalty Analysis
  - 2% video cache data need to be downloaded again
    - latency, energy, and money

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65%

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Discussion Topics

- Topic 1: How to systematically categorize cache files.
  - Challenge: When a cache file is downloaded, the system does not know its exact characteristics.
- Topic 2: How much RAM should be used for in-memory file system.
  - There is a trade-off.
    - Too small: not enough space to take advantage of FCFM.
    - Too large: negatively impact other files.
- Topic 3: Cache file eviction scheme.
  - Problem: page-based evict scheme such as LRU is not suitable.

Conclusion

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Thank you !

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