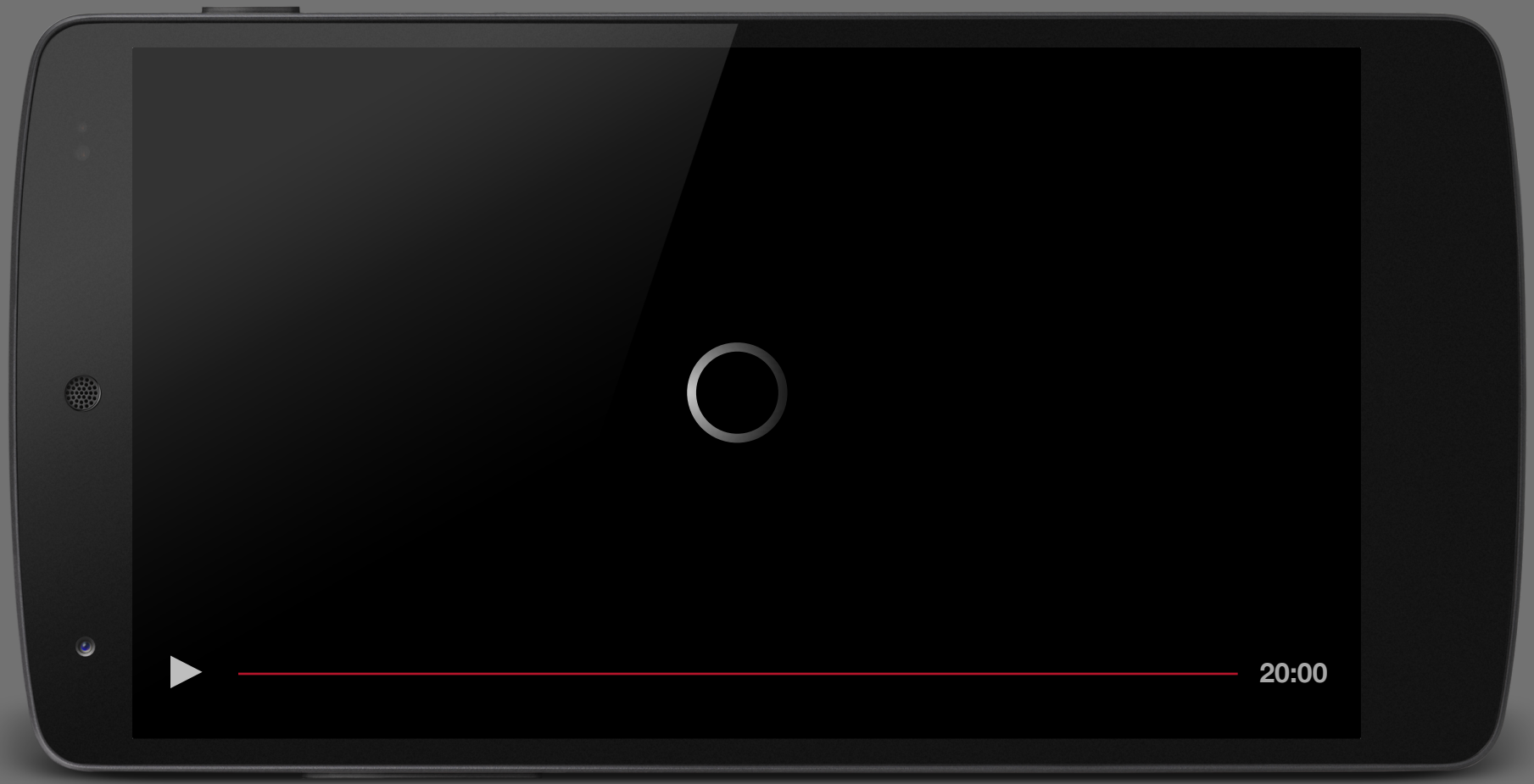
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Recommendation-Aware Mobile Prefetching Strategies for Video Sharing Sites

TECHNISCHE UNIVERSITÄT DARMSTADT

Masters Thesis Presentation

Dominik Schreiber, 29.5.2015

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Prof. Dr.-Ing. Wolfgang Effelsberg
Distributed Multimedia Systems

Motivation
Use Case

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Leverage Wi-Fi Access

- Prefetch video content **in background** while connected to WiFi
- Serve while on cellular networks **without additional requests**

Motivation
Numbers

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- video-sharing sites cause **≈64% of global internet traffic** [Cis15, p.2]
- **≈7.5 billion mobile devices** in the world [gsmaintelligence.com]
- personalized recommendations outperform "traditional approaches" **by ≈200%** [DLL+10, p.296]

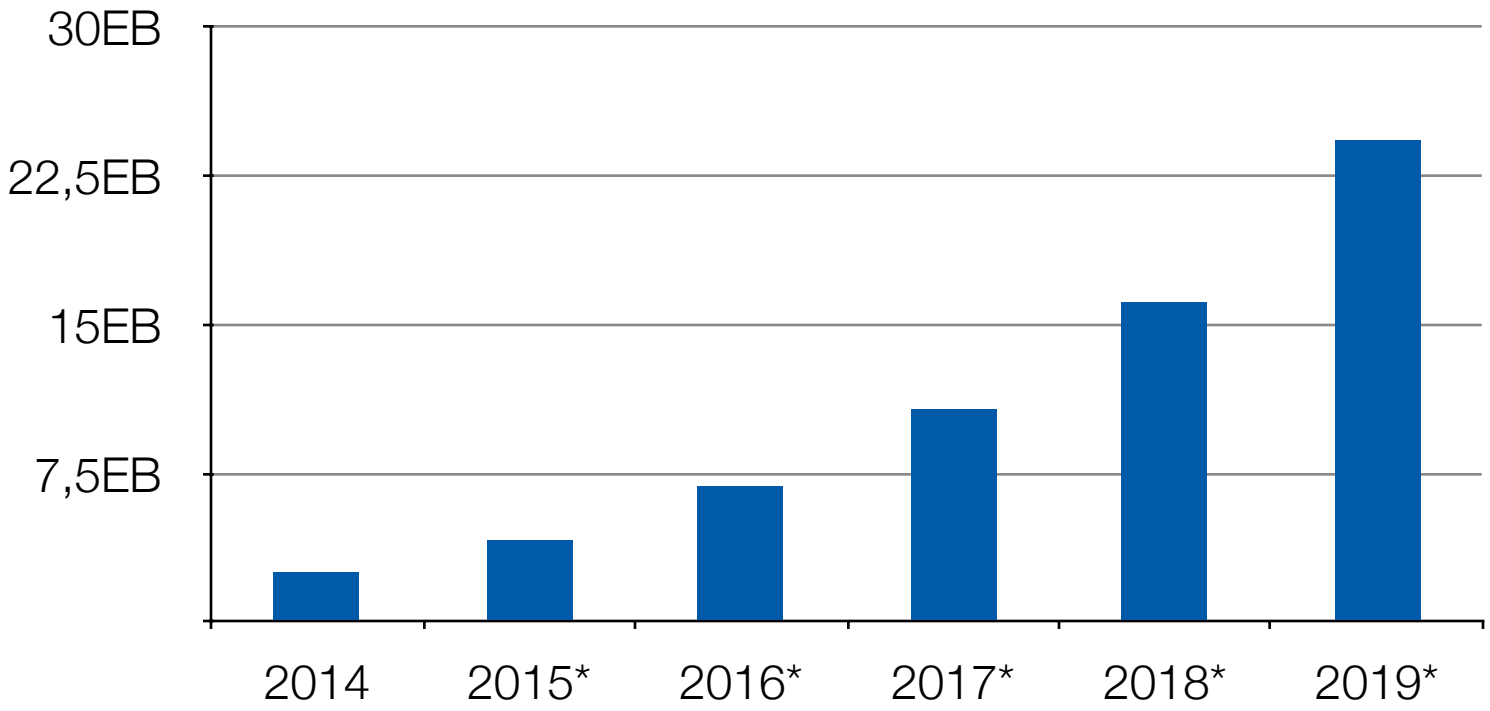

Fig. 1: Global mobile data traffic from 2014 to 2019 (in exabytes per month); plot of data from [Cis15, p.5].

Motivation
Research Objective

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Key Objective 1

realize personalized-recommendation-based prefetching strategy

Key Objective 2

evaluate against other prefetching strategies in the mobile setting

- implementation-heavy
- extensible architecture

Side Objective

facilitate transparent prefetching on mobile devices

- YouTube as practical target
- transparent to the user

Background
Caching

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Multiple layers

- per file
- per session
- per request

Multiple levels

- web server
- proxy/cdn
- client

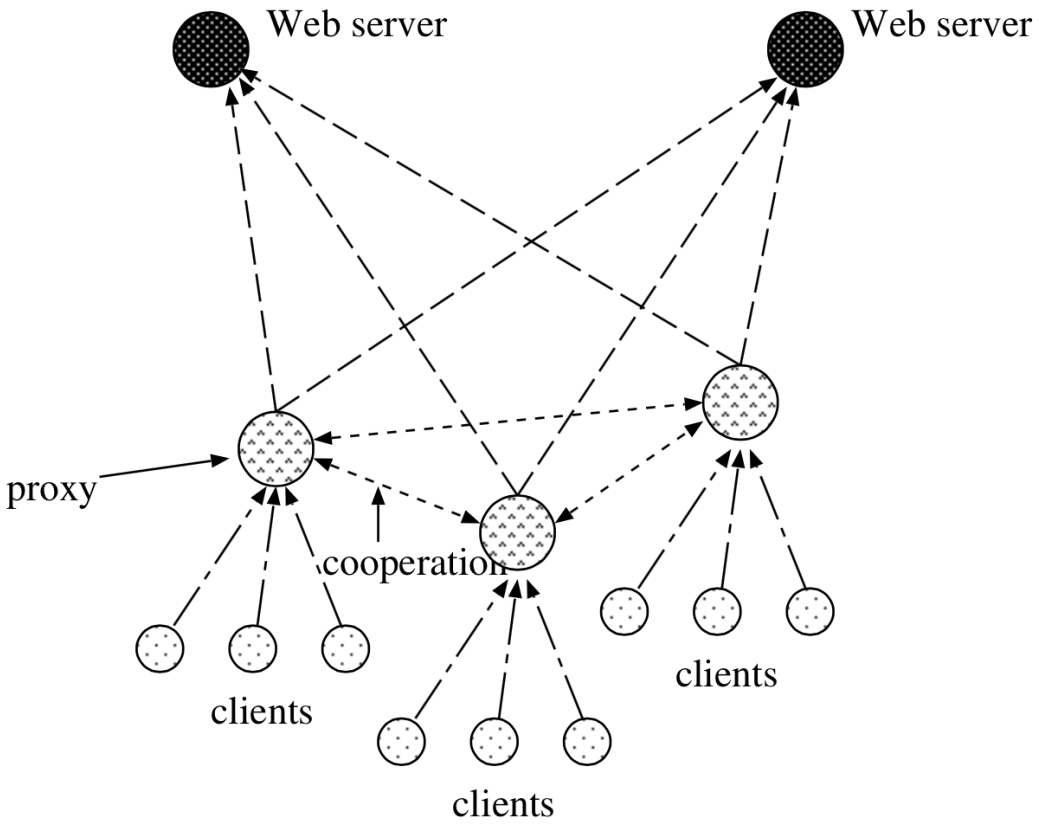

Fig. 2: Network hierarchy with multiple caching levels; from [Wan99, p.4]

Background
Prefetching

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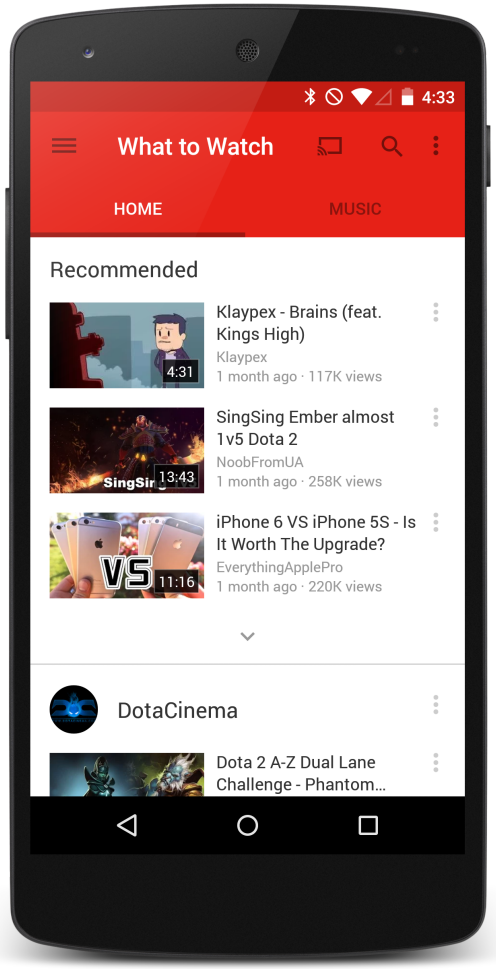

Idea

- download content **in advance**
- **device**-focused

Peer-to-Peer

objective:

- minimize **server load**

Mobile

objectives:

- minimize **traffic** over cellular connection
- maximize **cache utilization**

Related Work

NetTube [CL09] and SocialTube [LSW+12]

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Peer-to-Peer approach

- *Peers* form video-based *swarms* to **serve content** peer-to-peer
- *Peers* that share peers in any swarm form *neighborhoods* to **decrease** the **startup delay**

Prefetching strategy

when watching a new video:

- download **10s-prefixes**
- of **3** not yet prefetched
- videos from the **"related" list**

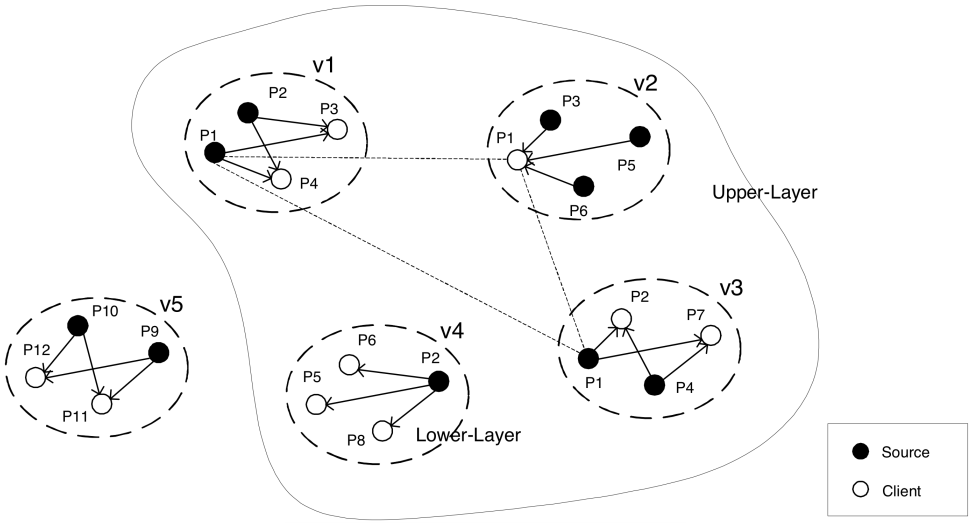

Fig. 3: Network topology of NetTube with *swarms for videos v1..v5* (dashed) and the *neighborhood for P1* (gray); from [CL09, p.4]

Related Work

NetTube [CL09] and **SocialTube [LSW+12]**

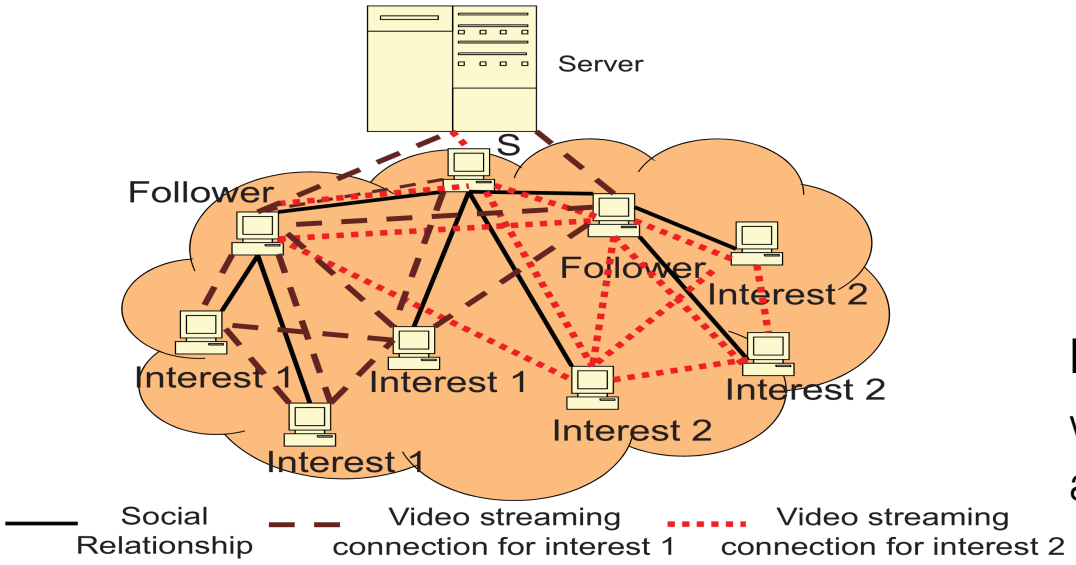

Fig. 4: Network topology of SocialTube for the source user *S*; from [LSW+12, p.2888]

Social-network based approach

- *1-hop friends* are categorized
- as **followers**
- or **non-followers**
- (or nothing)
- based on the ratio of videos watched from the source user

Prefetching Strategy

when publishing a new video, *push* a 10s prefix to

- all **followers**
- all non-followers that share the **interest cluster** for this video

Novel Approach

NewTube [Sch15]

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Single-device approach

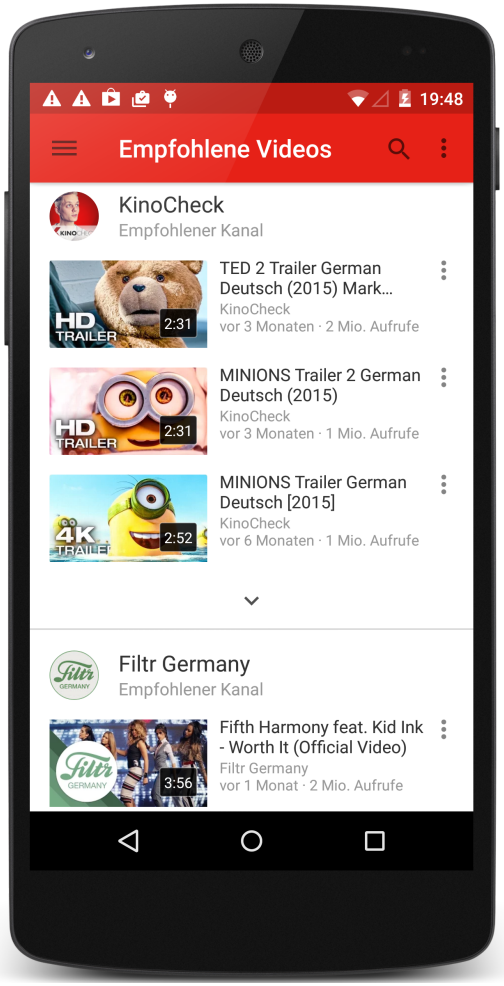
- **different setting** than NetTube/ SocialTube
- assumed to generally **perform worse**
- but **without dependency** to the peer-to-peer network

Prefetching strategy

always keep

- 10s prefixes of
- up to **50**
- **personalized** recommendations

prefetched



Novel Approach

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Prefetching strategy

always keep

- 10s prefixes of
- up to **50**
- **personalized** recommendations

prefetched

```
@Override
protected void process(
  final NewChunkEvent event,
  final Supplier<Boolean> done
) {
  new YouTube.Recommendations(
    new YouTubeTask.Options.Builder()
      .setMaxResults(50l)
      .setParts(_.list("id","contentDetails"))
      .build(),

    (recommendations) -> new YouTube.Videos(
      new YouTubeTask.Options.Builder().build(),
      (videos) -> new _<>(videos)
        .reject((video) -> isCached(video.getId()))
        .each((video) -> cachePrefixes(video.getId())),
      logException(Video.class)
    ).execute(new _<>(recommendations)
      .map((recommendation) -> recommendation
        .getContentDetails()
        .getRecommendation()
        .getResourceId()
        .getVideoId())
      .value()
      .toArray(new String[] {})),

    logException(Activity.class)
  ).execute();
}
```

Listing 1: Realization of the NewTube prefetching strategy; from [Sch15, p.38]

Design
Android + Transparent Proxy

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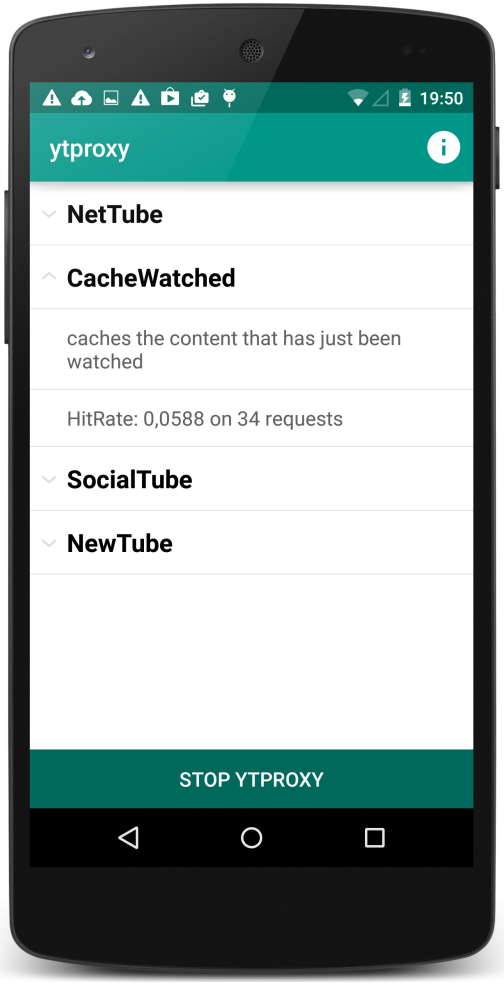
Host Operating System

- × *iOS* has **restrictive** App Store
- × *Windows Phone* has **small market share** (2.7%) [IDC14]
- ✓ *Android* is **user-friendly** and has **high market share** (84.7%) [IDC14]

Application Technology

- × a *standalone application* will not provide **generalizable** results
- × a service website in a *WebView* does not provide a **native UX**
- ✓ a *transparent proxy* allows use of **multiple services**



Architecture
Overview

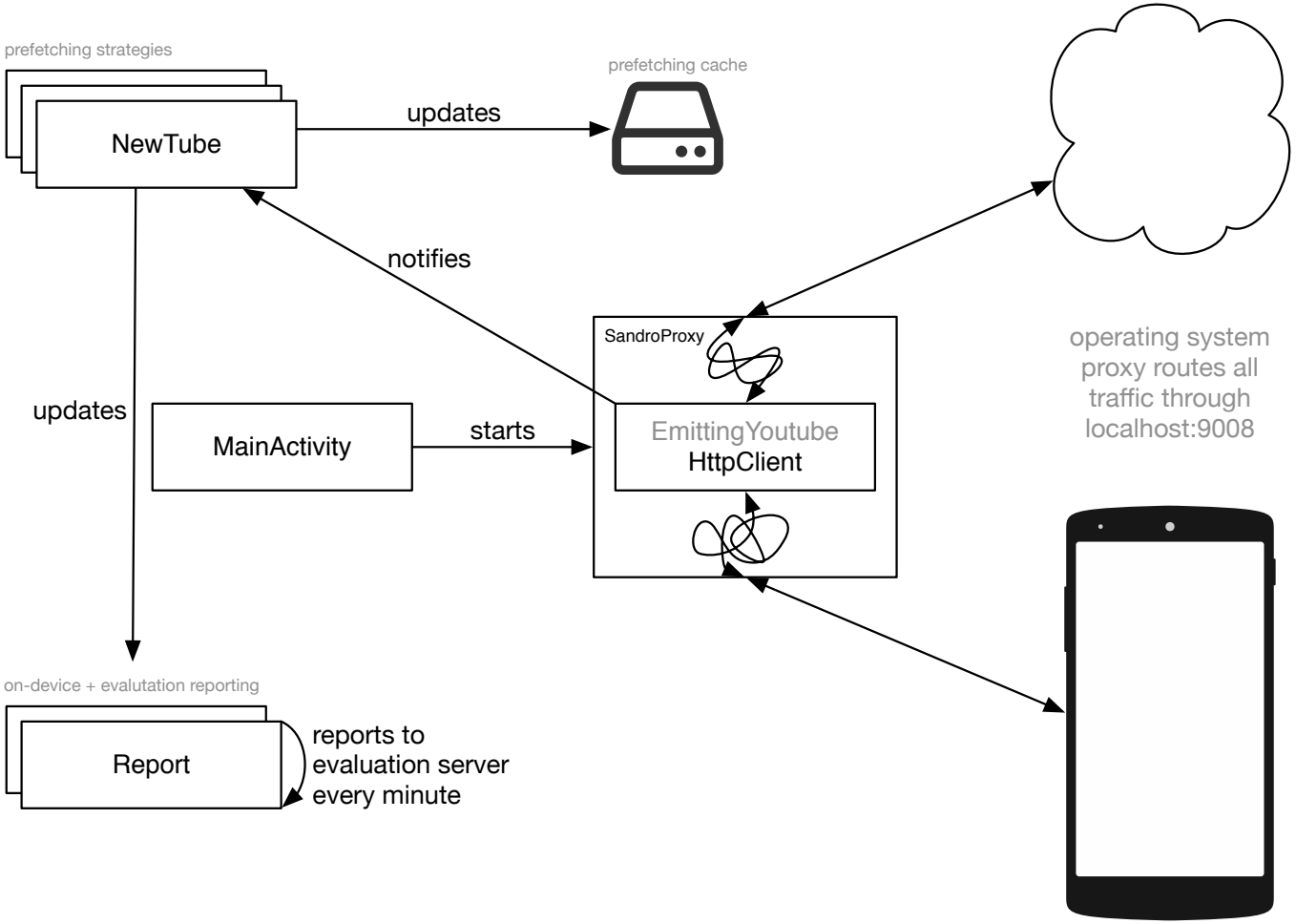


Fig. 6: Application Infrastructure of `com.dominikschreiber.ytproxy`; from [Sch15, p.28]

Evaluation
Overview

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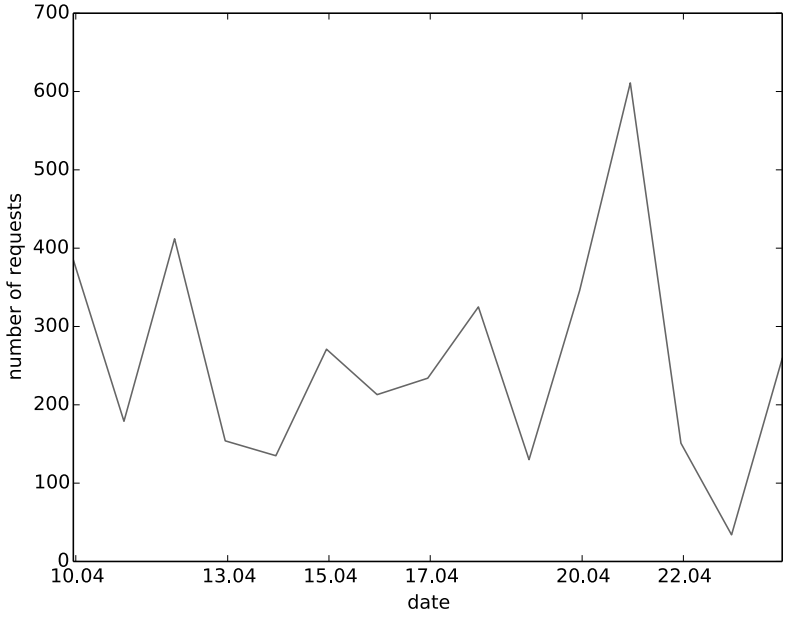
Setting

- 15 users (5 female, 10 male, ø 23.93 y/o)
- 19 days

Data gathered

- 4096 requests for 210 YouTube videos (for 1.63GB of YouTube content)



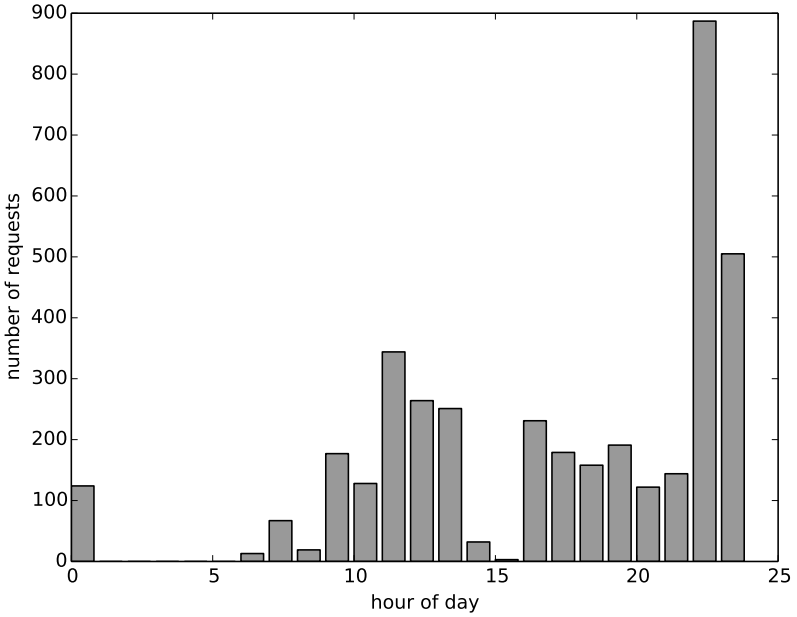


Fig. 7: Captured requests per *day* (left) and per *hour of day* (right); from [Sch15, p.49]

Evaluation
Cache Hit Rate

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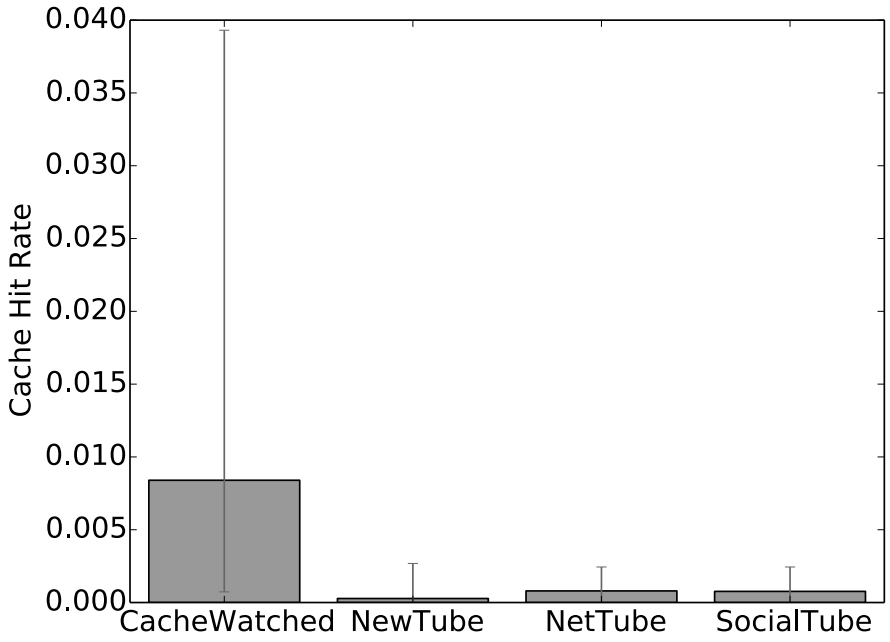
Cache Hit Rate

$$cacheHitRate = \frac{\#answered}{\#all}$$

Findings

- all strategies **perform bad**
- simply **caching** watched chunks works best



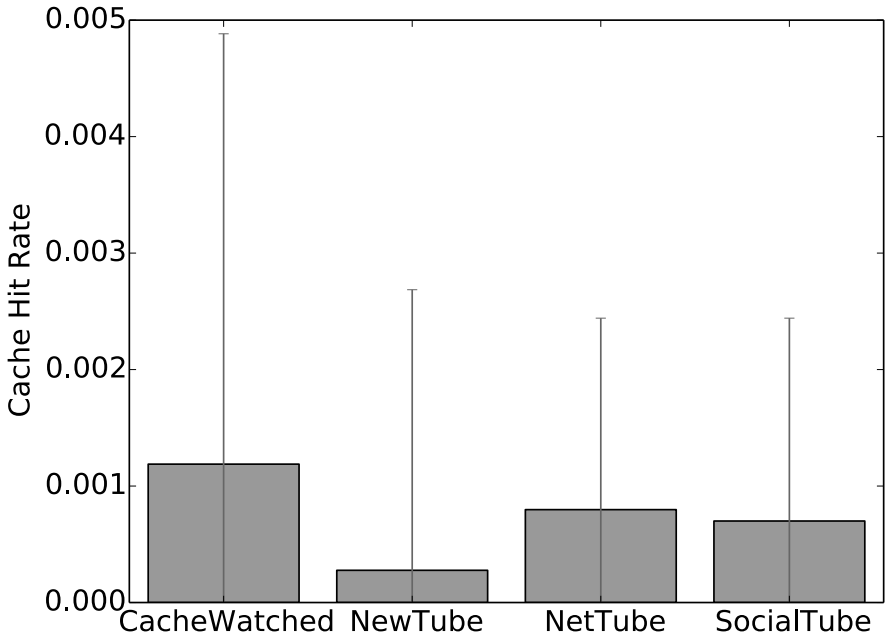


Fig. 8: Cache Hit Rate evaluation on *all requests* (left) and *excluding "re-requests"* (right); from [Sch15, p.53]

Evaluation
Prefetching Accuracy

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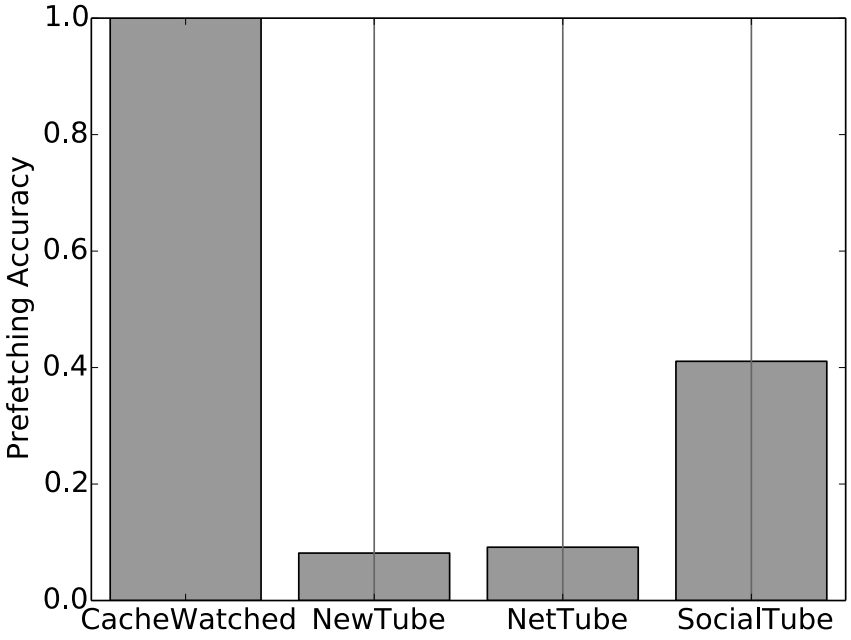
Prefetching Accuracy

$$prefetchingAccuracy = \frac{\#accessed}{\#cached}$$

Findings

- highly **unconfident** results
- **SocialTube** outperforms even the caching strategy



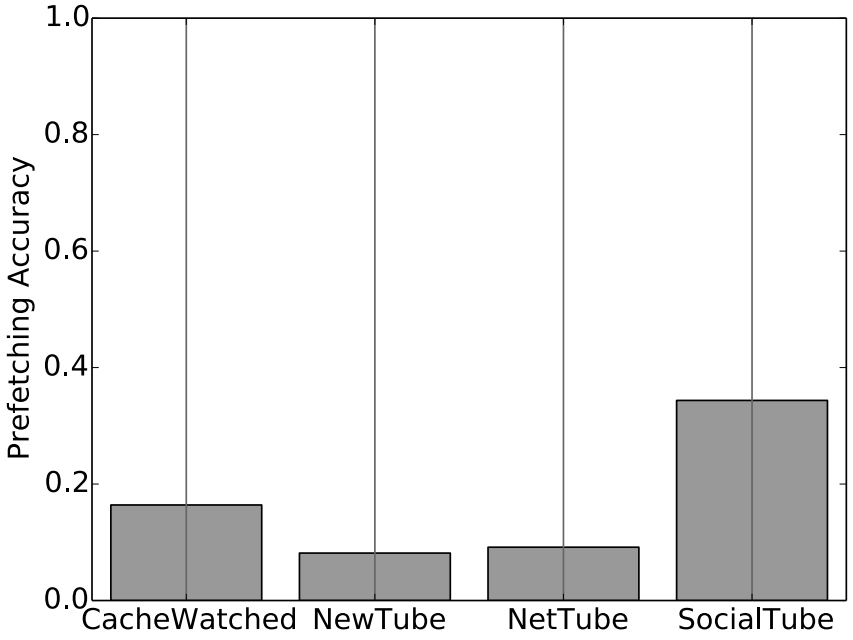


Fig. 9: Prefetching Accuracy evaluation on *all requests* (left) and *excluding "re-requests"* (right); from [Sch15, p.55]

Conclusion

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Retrospect

- extensible **Prefetching Application** for Android devices
- **naïve caching** scheme performs better than sophisticated strategies

Outlook

- **fine-tune naïve** approaches
- **optimize sophisticated** strategies
- combine strategies to an **adaptive** approach
- combine information sources to a **multi-source** approach
- replace simulation with **actual prefetching**

Lessons learned

- breaking SSL is a **time-consuming** task
- Android Java ≠ Java Java

Thank You

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Do you have

Questions?

Thank You

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Read it again

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github.com/dominikschreiber
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Use the open-sourced spin-offs

github.com/dominikschreiber/express-persistent-resource
github.com/dominikschreiber/underscore.java

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29.05.2015	Recommendation-Aware Mobile Prefetching Strategies for Video Sharing Sites	Dominik Schreiber	Denny Stohr

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[Sch15] Dominik Schreiber. Recommendation-Aware Mobile Prefetching Strategies for Video Sharing Sites. April 2015

Evaluation
Precise Data

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	all requests	only 10s prefixes	no re-requests
CacheWatched	0.0083984375	0.0333656644035	0.00118815104167
NewTube	0.000276692708333	0.00109925638539	0.000276692708333
NetTube	0.000797526041667	0.00316844487553	0.000797526041667
SocialTube	0.000764973958333	0.00303912059489	0.000699869791667

Table 1: Cache Hit Rate evaluation results; from [Sch15, p.52]

	1.0	***0.70095620151***	***0.164072242589***
	0.0814814814815	***0.0814814814815***	***0.0814814814815***
	0.0915698575145	***0.0915698575145***	***0.0915698575145***
	0.410770377125	***0.410770377125***	***0.343602457326***

Table 2: Prefetching Accuracy evaluation results; from [Sch15, p.54]

Evaluation
10s-prefixes

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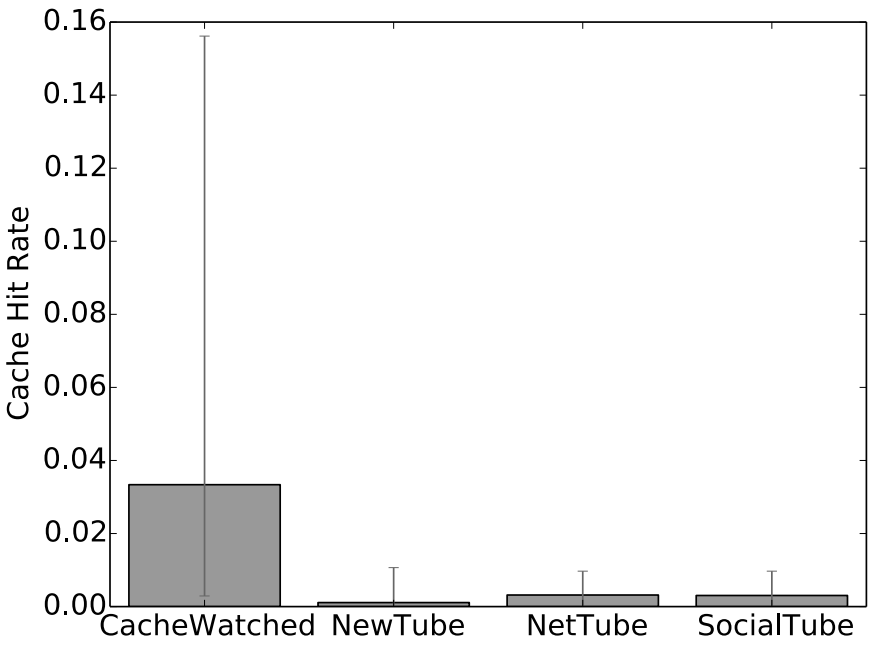
Cache Hit Rate

$$cacheHitRate = \frac{\#answered}{\#all}$$



Prefetching Accuracy

$$prefetchingAccuracy = \frac{\#accessed}{\#cached}$$

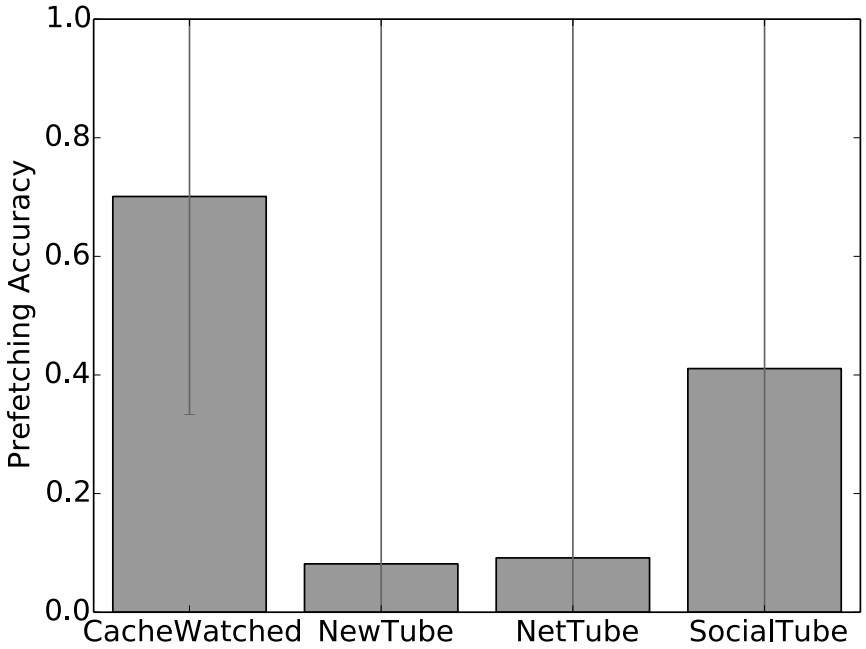


Fig.10: Cache Hit Rate (left) and Prefetching Accuracy (right) on requests in 10s-prefixes; from [Sch15, p.53,55]