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SEMANTIC MODELING, INTEGRATION, AND EPISODIC ORGANIZATION OF PERSONAL DIGITAL TRACES

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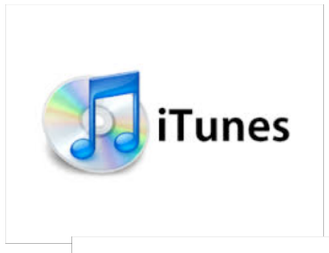
PERSONAL DIGITAL TRACES (PDTS) – FRAGMENTED, HETEROGENEOUS



WHAT WAS THE NAME OF THAT RESTAURANT…

- where I went with Mary?
- where we had dinner?
- where we went six months ago?

Some Sources of helpful data

- "with Mary": calendar, email, text (Facebook/Messenger)
- "restaurant": check-ins (Foursquare/Facebook), cell phone GPS logs
- "restaurant": credit card statements, reservations (OpenTable)

MOTIVATION

- Such a collection of personal digital traces (PDTs) can be useful in:
  - helping the user **recall** forgotten details.
  - enabling users **understand** and **query** their PDTs.
- Need for **integrated view** of the user's activities in a sensible uniform manner.
  - basis to connect entities and events into **autobiographical memories**.

CONTRIBUTIONS SO FAR

- **Integrate personal digital traces** by developing techniques to retrieve, store and index PDTs from various heterogeneous sources - **Personal Extraction Tool**
- **Group personal digital traces** with respect to conceptually coherent **episodes** for common everyday events - **extensible approach - Personal Knowledge Base** ExploreDB '17@SIGMOD/PODS
- **Design of a unified and intuitive formalized conceptual model** to link and represent both **PDTs** and their corresponding **episodes.** ODBASE '17
- **Case study** for evaluating our approach with real user's data.
- **Design of an interactive tool** (mobile application) with narrative views of users' digital memories. CIKM '18

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INTEGRATING PERSONAL DIGITAL TRACES

- Create an infrastructure to retrieve and store PDTs.
  - **Gather content** from several online services (via APIs, IMAP)
    - Social data - Facebook, Instagram, Twitter, LinkedIn
    - Geolocation data - Foursquare, Facebook, Instagram
    - Email - Gmail, or any other email
    - Calendars - Google Calendar
    - Personal files - Google Drive, Dropbox
    - Web browsing histories - Chrome, Firefox
- Apply entity resolution – who, where dimension
- Apply time extraction - explicating/disambiguating information

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- **Design of an interactive tool** (mobile application) with narrative views of users' digital memories - **extensible approach**

BACKGROUND

➤Research in psychology has shown two forms of explicit memory

1. Semantic memory – memory of facts and concepts
2. **Episodic memory** – memory of autobiographical events

➤Natural way to remember past events is by any pertinent contextual information; answers to:

➤ ***What, When, Where, Who, Why, How (w5h)***

➤PDTs are inherently contextual due to various forms of metadata

- **When** an email was sent
- **Who** was involved in a conversation
- **Where** a meeting took place
- **What** a file contains
- **Why** a website was accessed
- **How** the information was recorded

CONCEPTUAL MODELING OF PERSONAL DIGITAL TRACES

```
class DOCUMENT is a ENTITY{
  features:
     size : INT;
properties:
     hasPart: set of ENTITY;
     who: set of PERSON;
     what<hasPart: set of DOCUMENT;
     when: set of TIME;
     where: set of LOCATION;
     why: set of GOAL;
}
```

```
class SEND is a ACTION{
  sender<who: PERSON;
  recipients<who: set of PERSON;
  whenSent<when: TIME, …
  }
```

```
class  EMAIL is a DOCUMENT {
  features:
     threadId: STRING;
  properties:
     from<who: PERSON;
     to<who: set of PERSON;
     cc<who: set of PERSON;
     subject < what: TEXT;
     content < what :TEXT;
     attachments < what: set of DOCUMENT;
  actions:
     send: SEND
     reply: REPLY
  constraints:
     from =send.sender;
     send.whenSent<when;   …
  }
```

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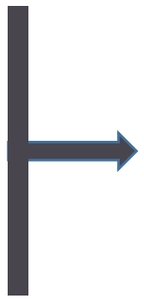
GROUP PDTS INTO COHERENT EPISODES

- Goal: Organize & summarize PTDs into episodes
  - Emails concerning a dinner
  - OpenTable reservation at a restaurant
  - Facebook checkin with photos
  - Credit card payment



Part of the narrative for going out to eat

- To do so, we use a set of higher level ***prototypical plans*** that the user and her/his community frequently engage in.
- **Scripts** : **prototypical plans**, "a predetermined, stereotyped sequence of actions that defines a well-known situation" (Schank & Abelson '77).
- Scripts are composed of sub-scripts, and abstract some of their details.

GROUP PDTS INTO COHERENT EPISODES

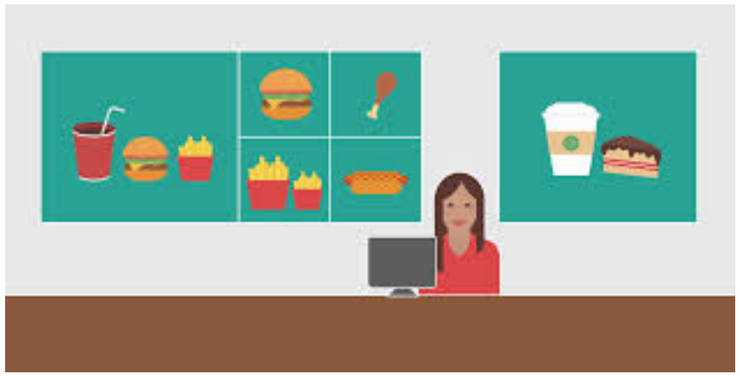
- Example - Going out to eat at a restaurant
  - **Script** would provide description of possible "event flows"

Arrange where & when to go

Make reservation

Call a cab/uber

Go to restaurant



Order food

[….]

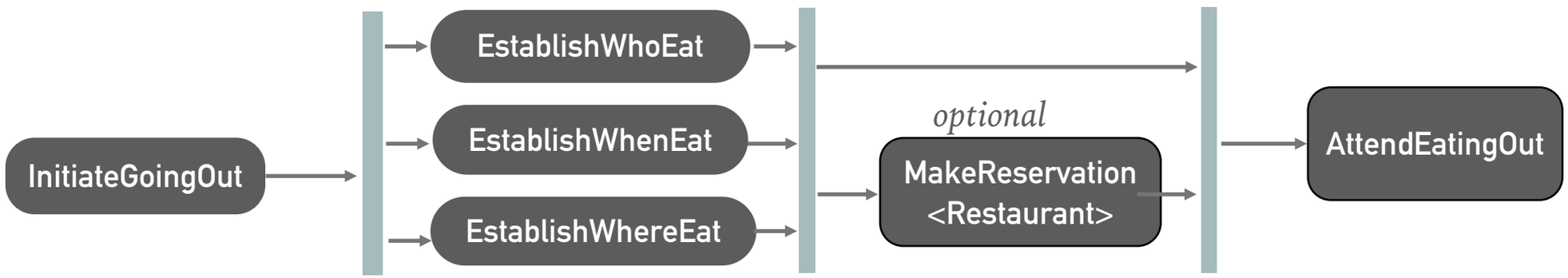
Pay

[….]

ONTOLOGY FOR SCRIPTS & SCRIPT PROPERTIES

```
class Eating_Out is a SCRIPT{
  locals:
    whoAttended <who : set of PERSON
    whereEating < where : EATERY
    whenEating< when :TIME
    whatEaten<what: set of FOODS
    purpose<why : GOAL
  body:
    InitiateGoingOut ;
    (And
      EstablishWhenToEat,
      EstablishWhoWillEat,
      EstablishWhereToEat) ) ;
      (Optional
        MakeRestaurantReservation);
      AttendEatingOut)
}
```

```
class AttendEatingOut is a SCRIPT{
  body:
    GetToEatery ; CheckIn;
    (OR(OrderFood; BeServed), SelfServeFood) ;
      Eat; MakeAPayment; LeaveEatery;
}
```



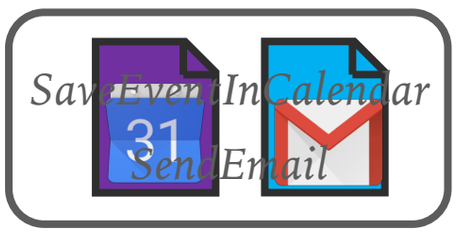
UML activity diagram for Eating_Out

ALGORITHM FOR INSTANTIATING SCRIPT INSTANCES

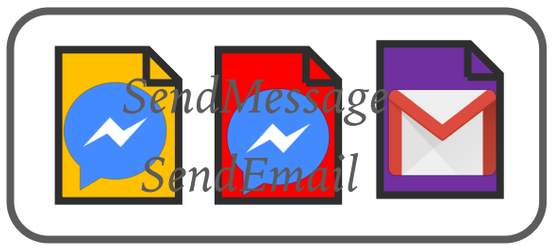
Personal digital traces

Retrieve *relevant PDTs*

Strong evidence



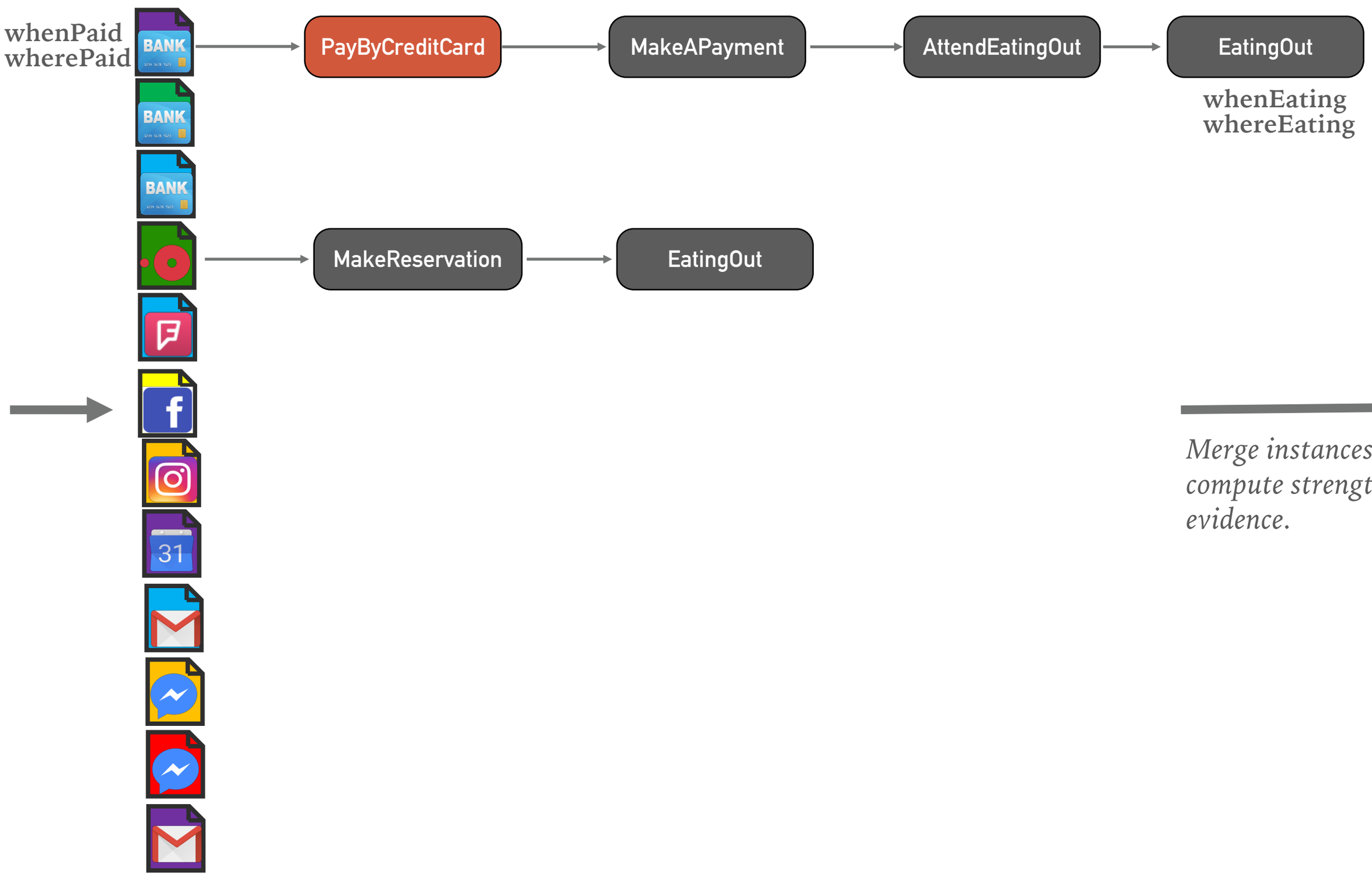
Mild evidence



Weak evidence

Create script instance with some information filled in

ALGORITHM FOR INSTANTIATING SCRIPT INSTANCES



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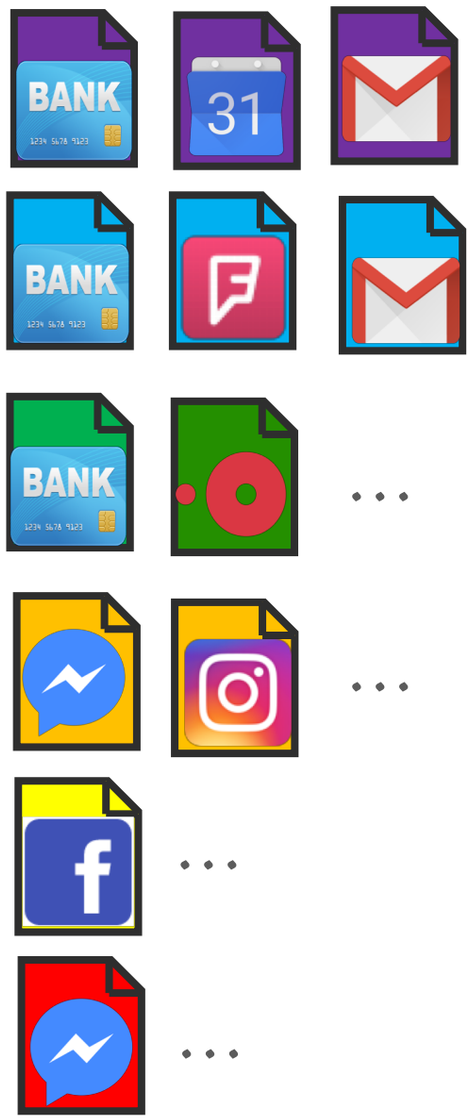


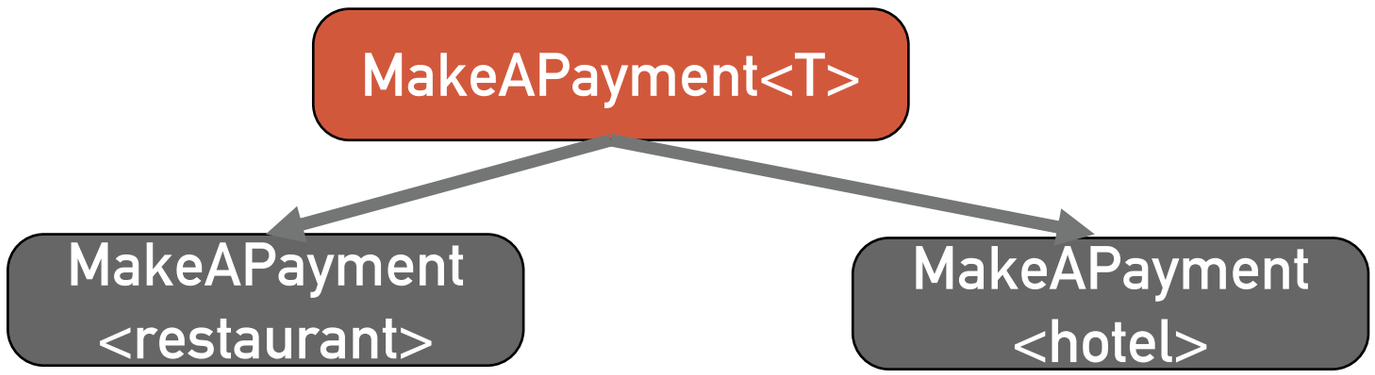
who…
where…
when…

who…
what…
when…
where…

Get more PDTs based on the script body

EXTENSIBLE APPROACH FOR SCRIPT INSTANTIATION

1. Creation of **"trigger words/phrases"**
   - **Verbs** for goal events + synonyms, hyponyms -Wordnet, ConceptNet5
   - **w5h participants** of the goal event - Verbnet, Framenet
2. Declarative definition of **Scripts**
   - Top-level script, subscripts, atomic tasks, locals (w5h info), sequencing, relationship
   - All the scripts/subscripts are **parametric/generic**



3. Declarative Description of **Evidence/Clues** (strong/weak)
4. Declarative definition for **mapping PDTs locals to Script locals**

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CASE STUDY: EATING OUT

- *Goal*: Find, among users PDTs instances of eating at various restaurants.
- **Three** users: Alice, Bob, Charlie
- **Six-month** period PDTs
- **Four** types of sources:
  - **messaging** (e.g., email, Facebook messenger, Hangouts)
  - **calendaring** (e.g. Google Calendar)
  - **financial transactions** (e.g. bank and credit card statements)
  - **location services** (e.g. Foursquare, Facebook checkins).

GOLDEN SET

- The identification of the golden set a posteriori is difficult.
- Every user went carefully over their recorded PDTs and identified all data that pertained to Eating Out events.

Alice	Bob	Charlie
63	21	(116) 40

Number of identified `Eating_out` events per user

RELEVANT PDTS TO THE EATING_OUT SCRIPT

	Alice	Bob	Charlie
Email/Messaging	**56**	**52**	26
Calendar	**-**	**14**	**7**
Financial Data	44	17	**136(49)**
Location	**9**	-	-

Number of PDTs relevant to the `Eating_Out` script per source per user

EVALUATION METRICS

- **Percentage of events retrieved**

$$\frac{\text{\# relevant instances retrieved}}{\text{\# all } \mathbf{relevant} \text{ instances}}$$

- **Overall Precision**

$$\frac{\text{\# relevant instances retrieved}}{\text{\# all } \mathbf{retrieved} \text{ instances}}$$

- **Precision@k**

EXPERIMENTAL RESULTS – RECALL

	Alice	Bob	Charlie
Email/Messaging	0.59	0.86	0.06 (0.18)
Calendar	-	0.29	0.05 (0.15)
Financial Data	0.67	0.52	0.89 (0.68)
Location	0.14	-	-
Email/Messaging+Financial Data	0.98	1	0.95 (0.85)
Calendar+Financial Data	0.67	0.76	0.95 (0.83)
Location+Financial Data	0.68	0.52	0.89 (0.68)
Calendar+Email/Messaging	0.59	0.86	0.11 (0.33)
Email/Messaging+Location	0.7	0.86	0.06 (0.18)
All sources	1	1	1

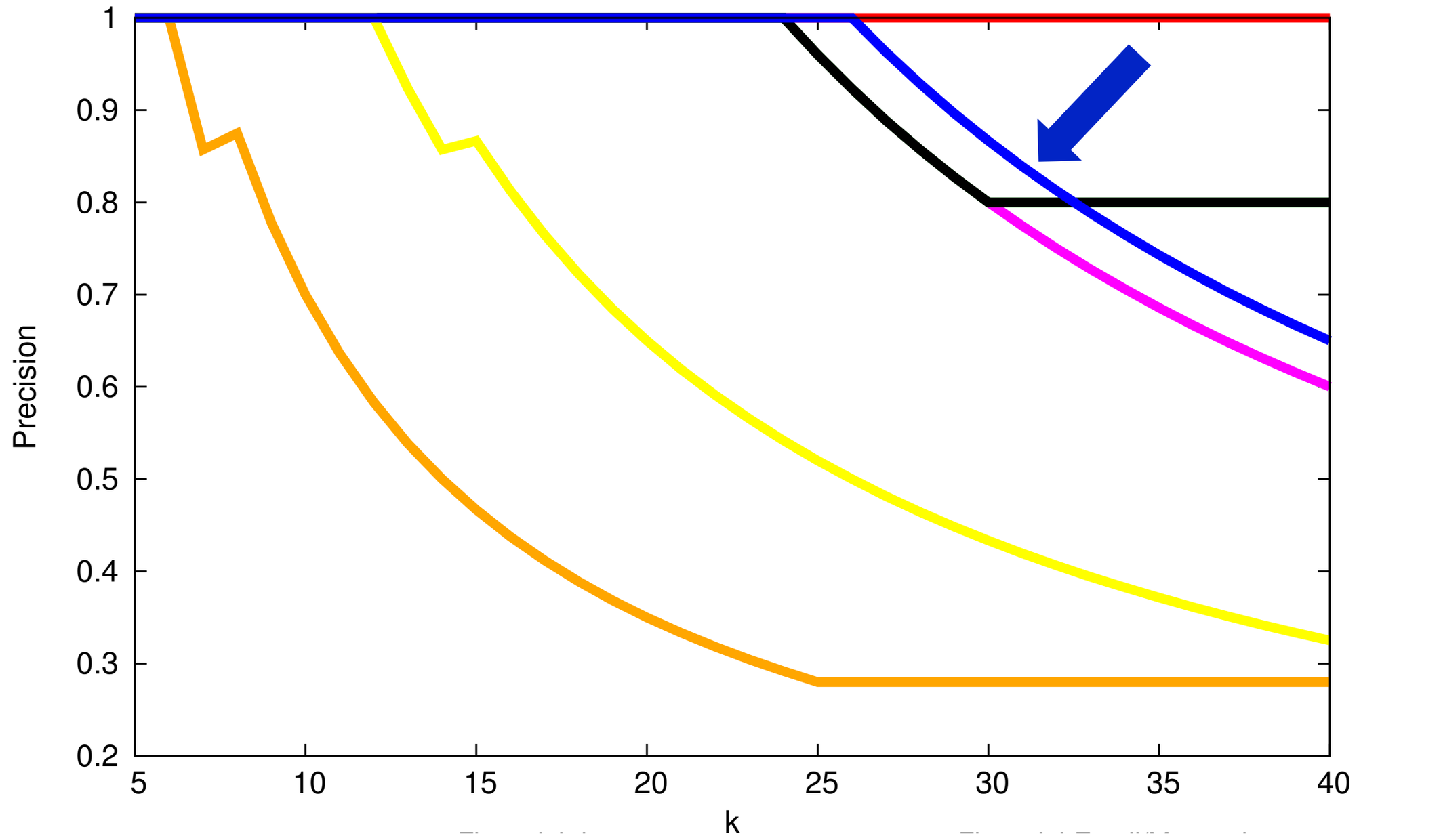
Percentage of Eating_Out episodes retrieved per (set of) sources, per user

EXPERIMENTAL RESULTS – PRECISION

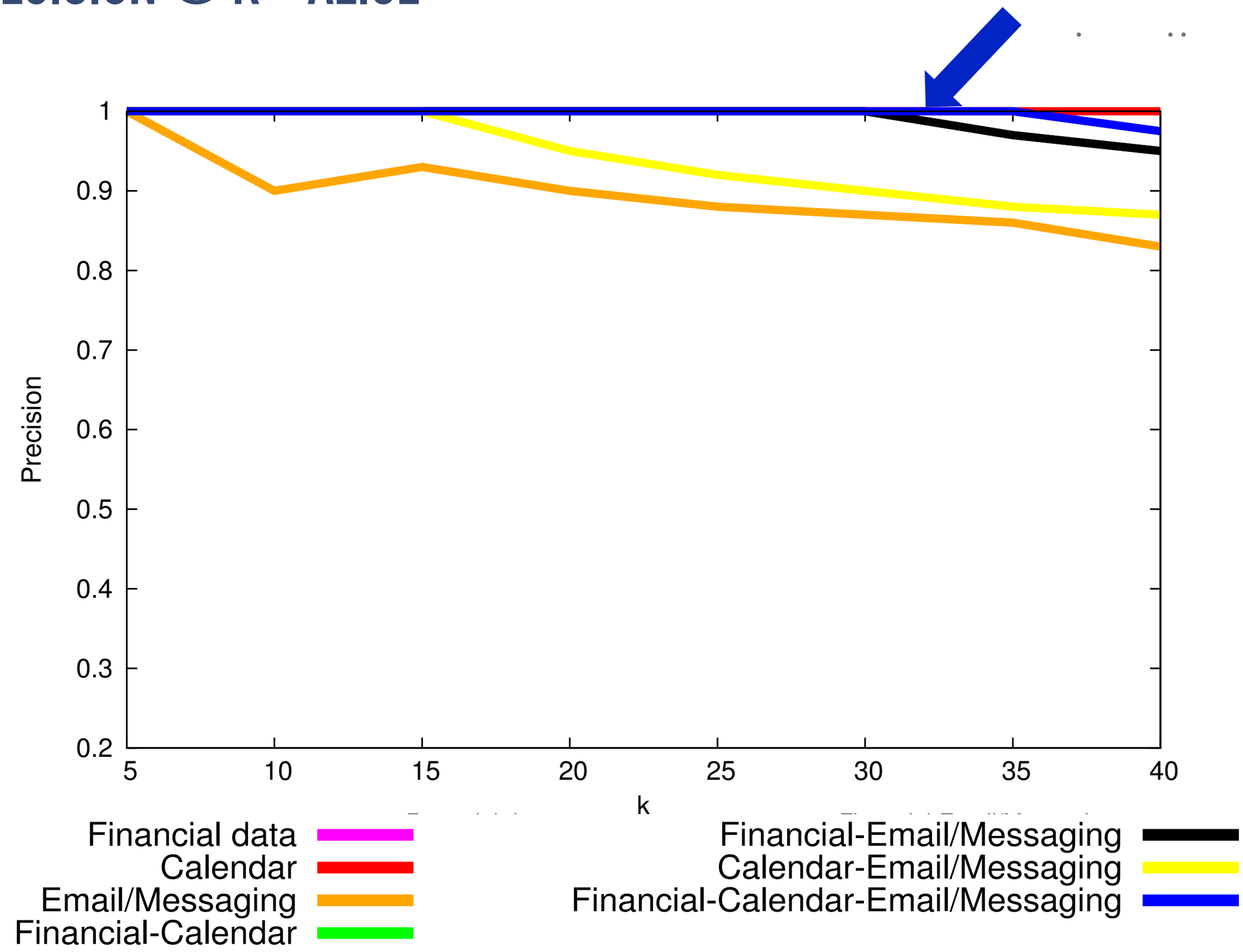
	Alice	Bob	Charlie
Email/Messaging	0.66	0.33	0.33
Calendar	-	0.43	0.86
Financial Data	0.95	0.65	0.82 (0.55)
Location	1	-	-
Email/Messaging+Financial Data	0.75	0.32	0.69 (0.4)
Calendar+Financial Data	0.95	0.52	0.83 (0.59)
Location+Financial Data	0.96	0.65	0.82 (0.55)
Calendar+Email/Messaging	0.66	0.32	0.46
Email/Messaging+Location	0.7	0.35	0.33
All sources	0.75	0.32	0.69 (0.48)

Overal Precision per (set of) sources, per user

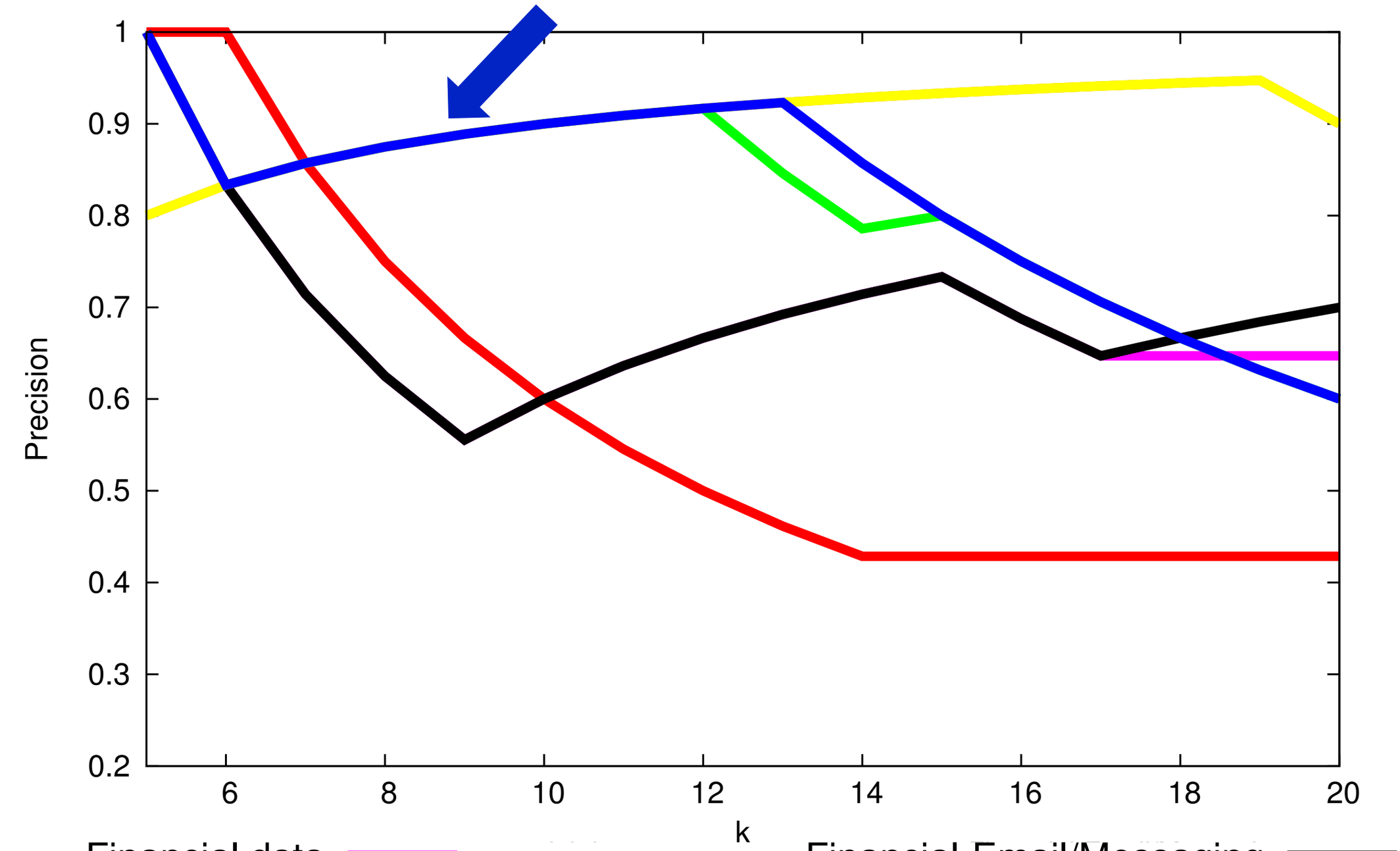
PRECISION @ K – CHARLIE



PRECISION @ K – ALICE



PRECISION @ K – BOB



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YOUR DIGITAL SELF

- A mobile-based personal information organization application.
  - To be used to implement and evaluate our research through user studies and surveys.
- Provide users with narrative views of their digital memories.

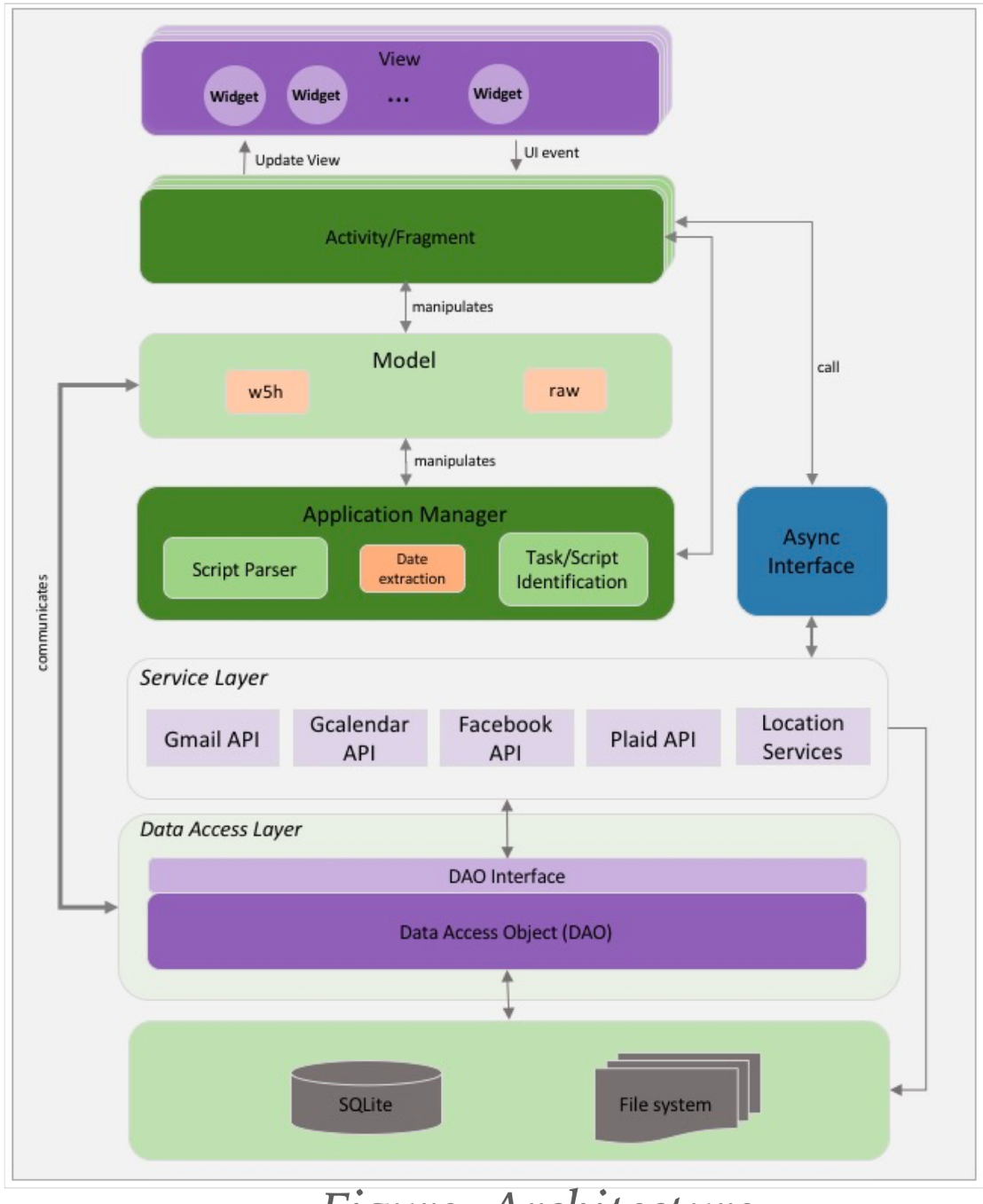
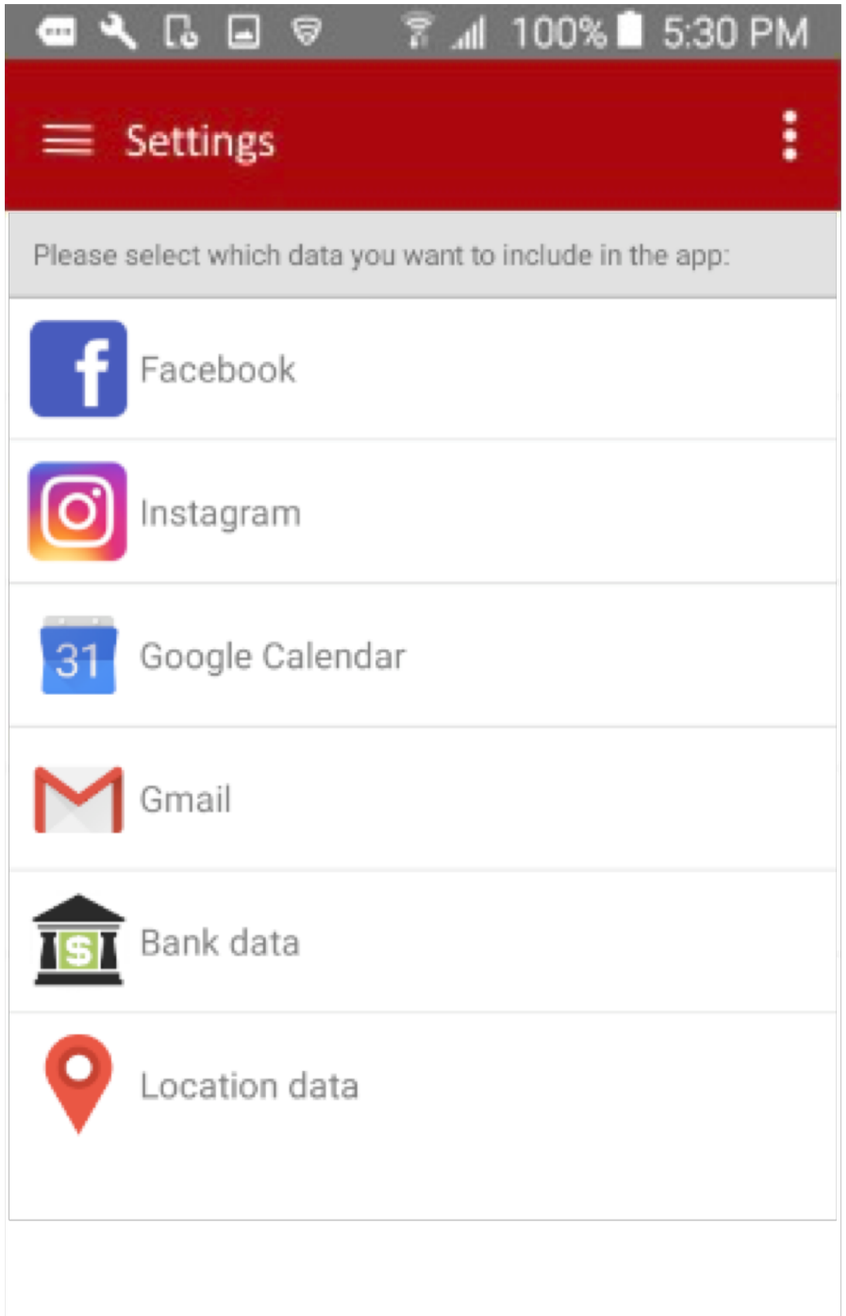
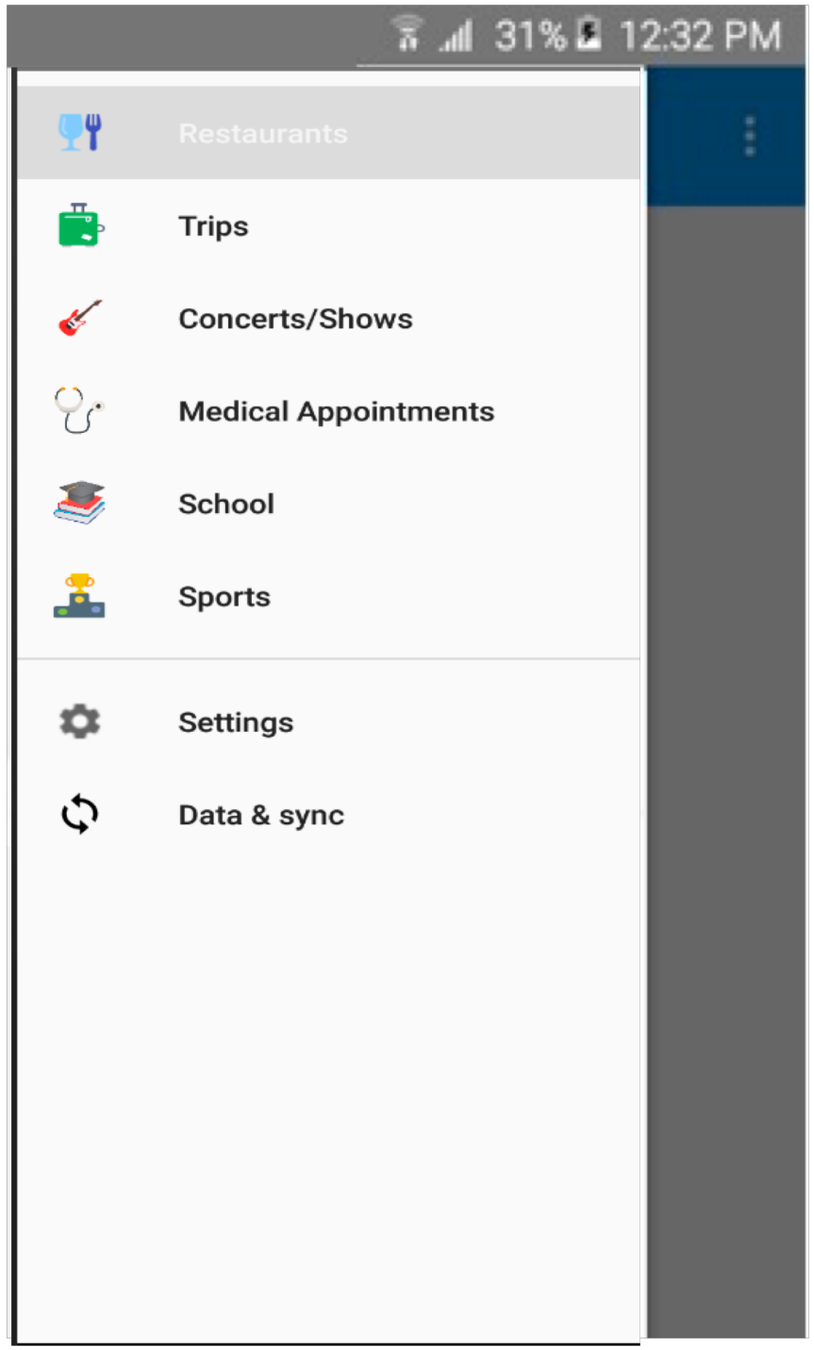


Figure: Architecture

YOUR DIGITAL SELF

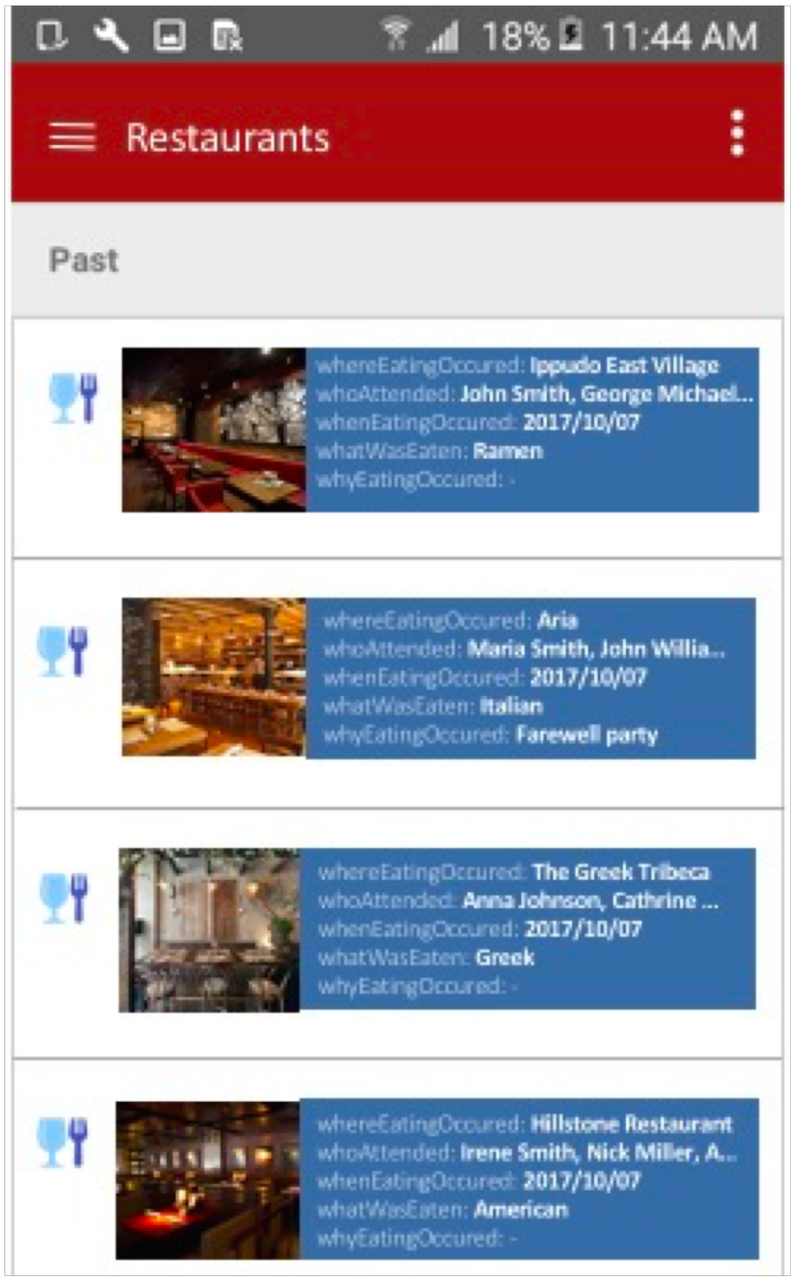


(a) List of sources

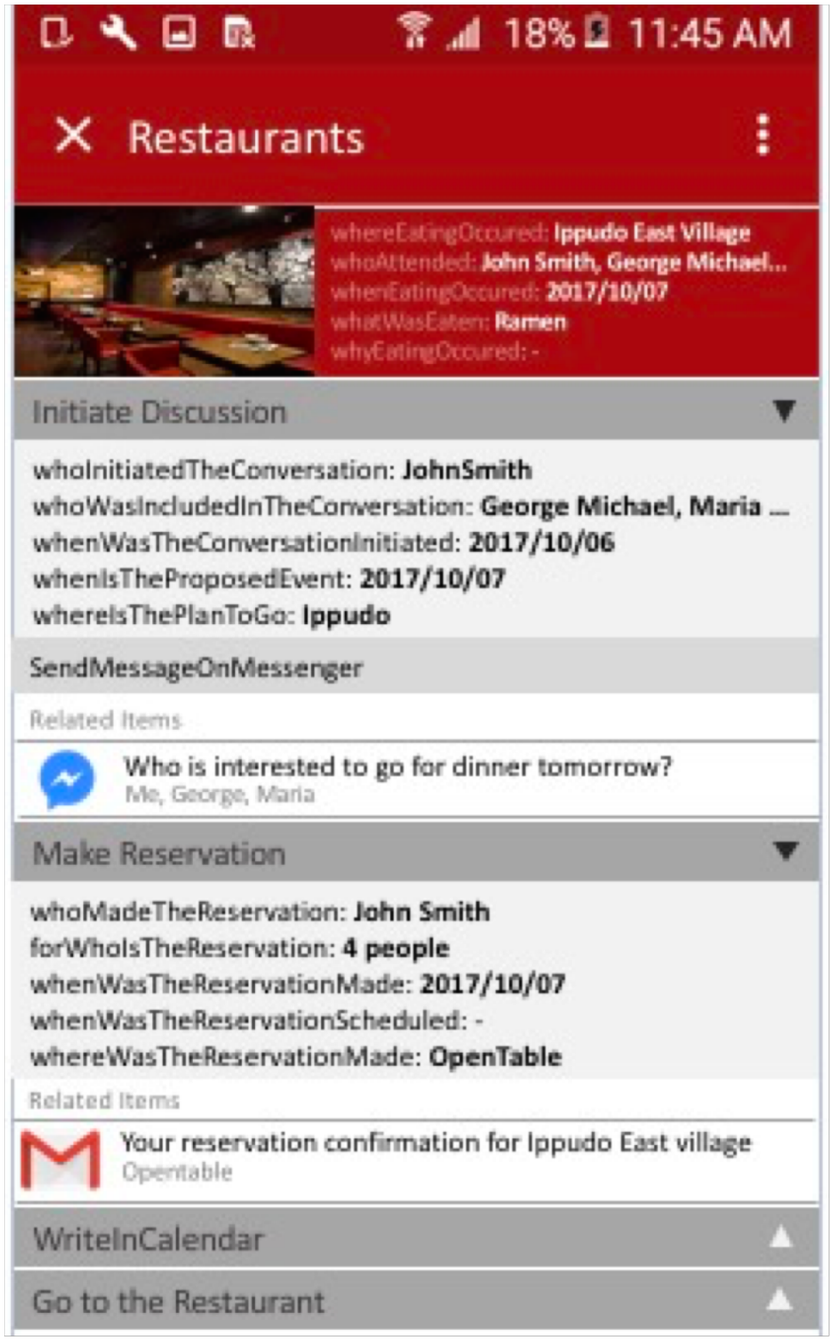


(b) List of script categories

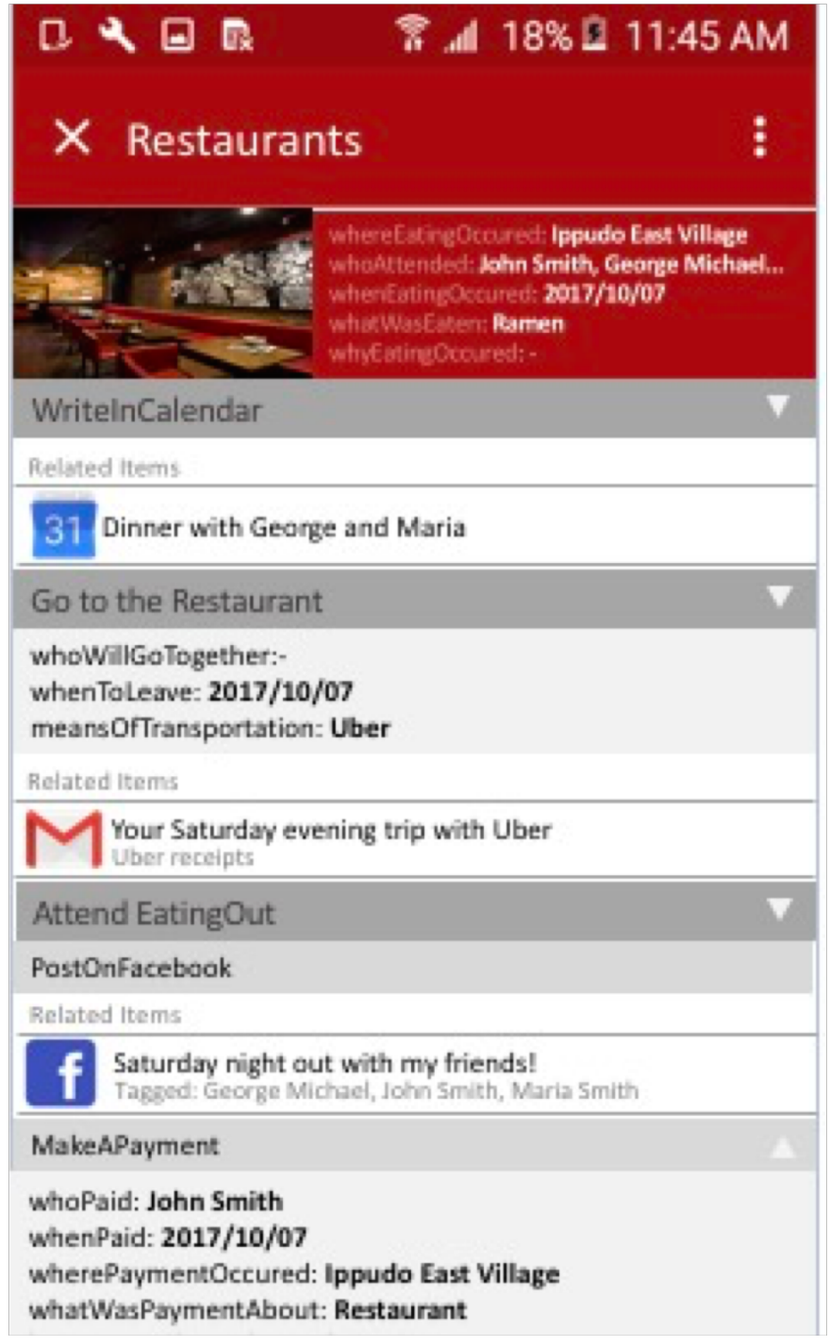
YOUR DIGITAL SELF



List of recognized restaurant outings

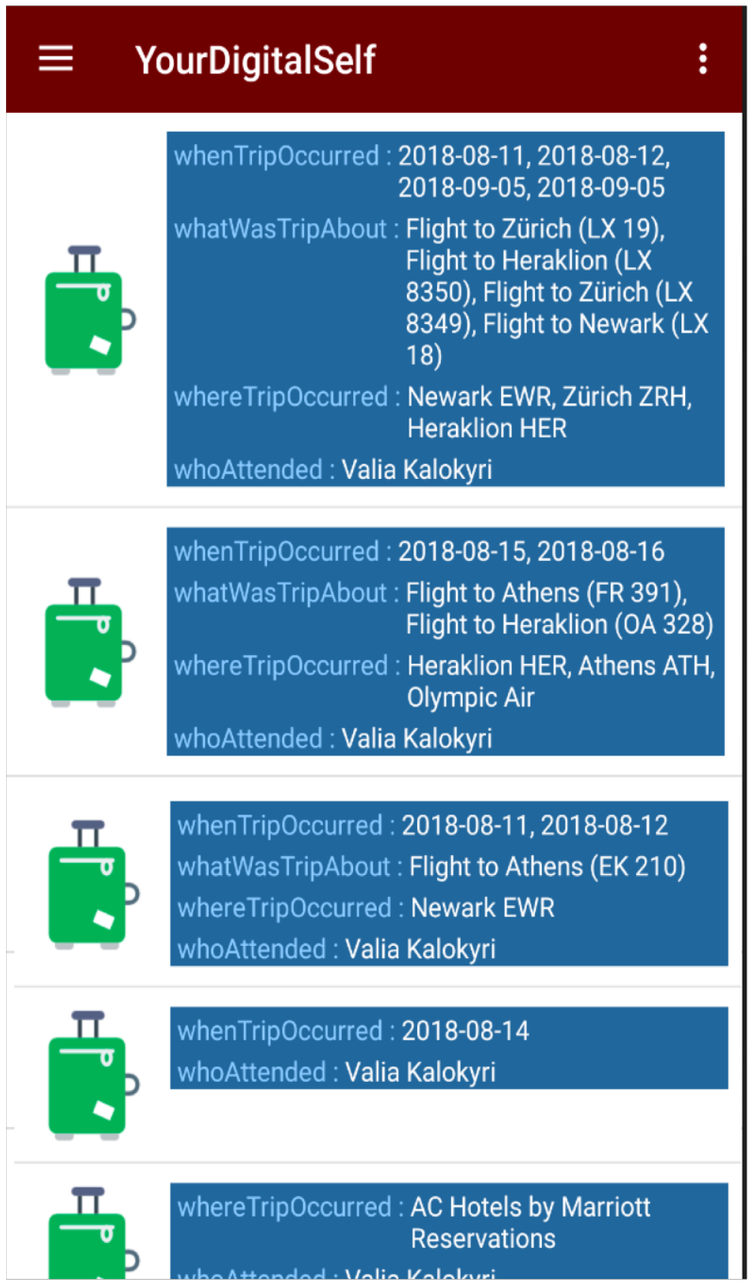


Instantiation of a restaurant outing (1/2)

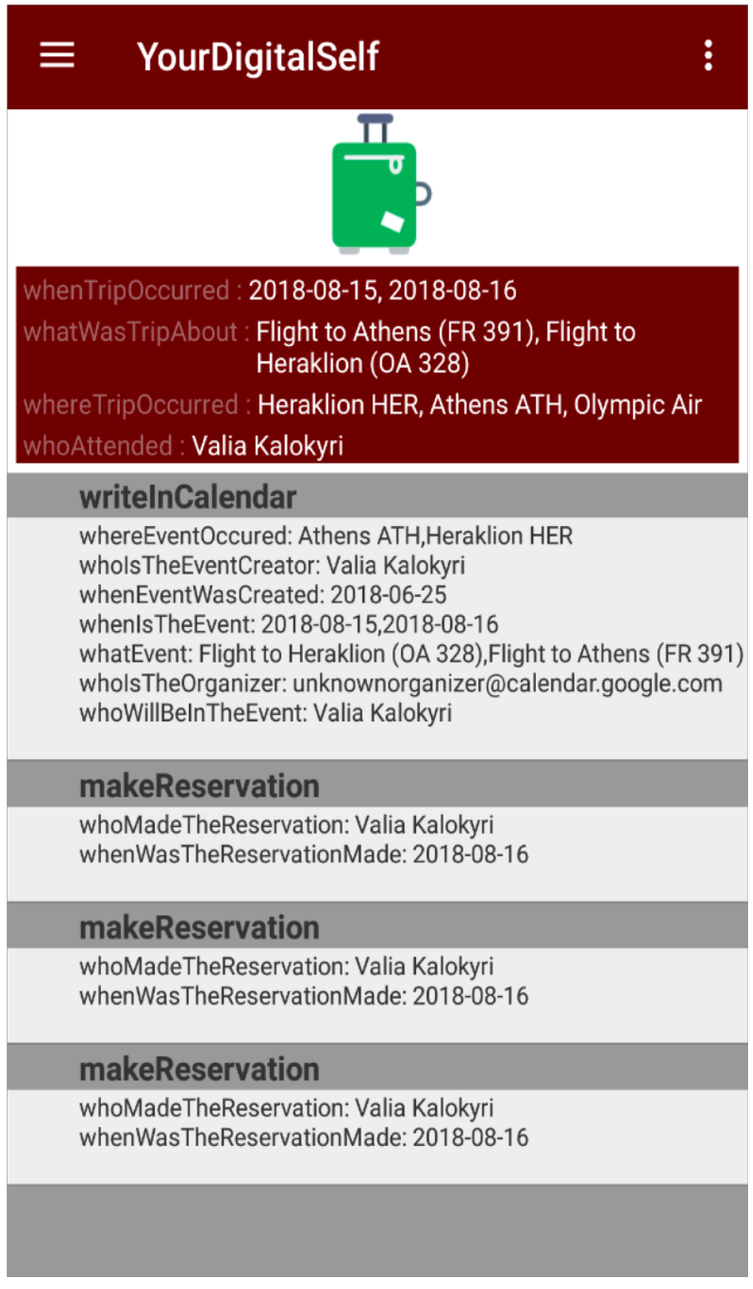


Instantiation of a restaurant outing (2/2)

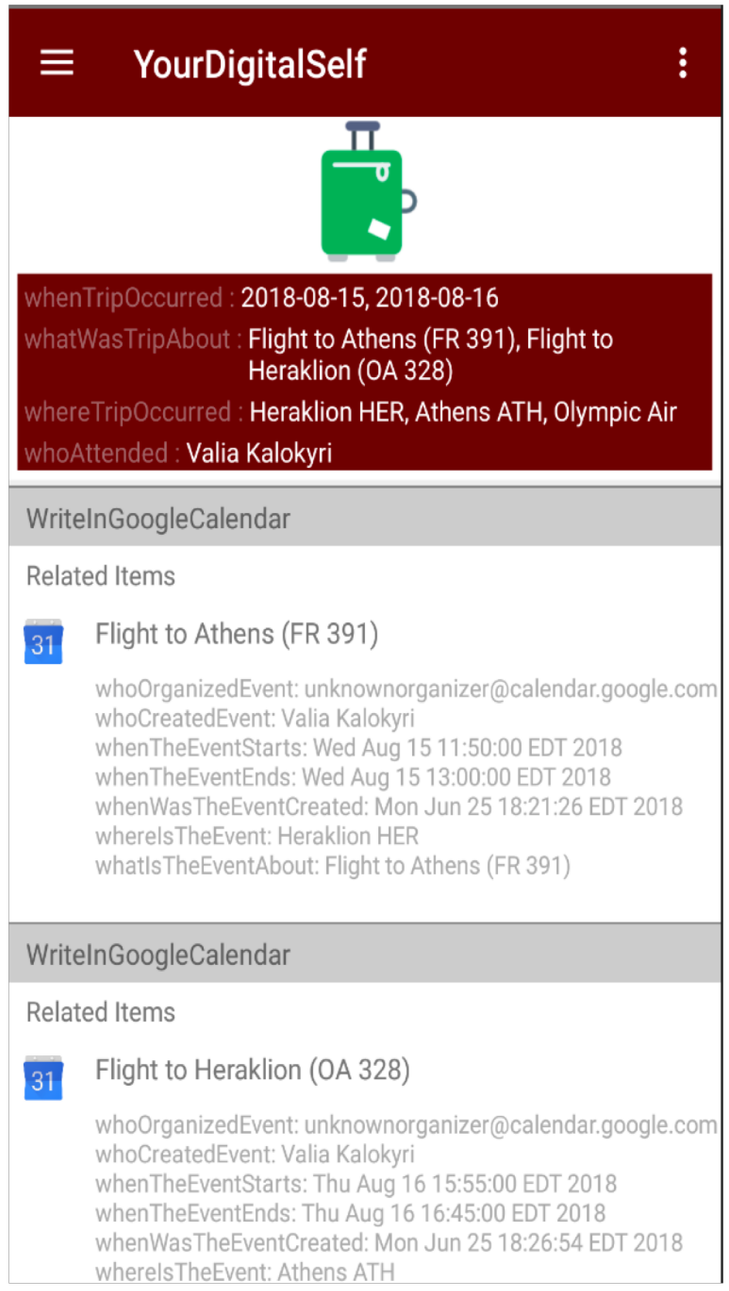
YOUR DIGITAL SELF



List of recognized trips



Instantiation of a trip instance(1/2)



Instantiation of a trip instance (2/2)

RELATED WORK

- **Personal Information Management Systems - PIMs**
  - Focus on object relationships
    - **Haystack, pStore, Semex, OntoPIM**
  - Episodic memory is much more extensive and relevant in making sense of a **collection** of documents.
- **Processes and Plans**
  - Rely on Machine Learning of patterns/process schemas from large collection of examples (sensor data).
  - In our case, a very large fraction of the plan steps in any particular instantiation of a script leave no trace ("missing actions")
- **New approach based on Information Retrieval.**

CONCLUSION

- **Integrate personal digital traces** by developing techniques to **retrieve**, **store** and **index PDTs** from various heterogeneous sources.
- **Design of a formal conceptual model and script language** for **linking** and **representing** both **PDTs** and prototypical plans (**scripts**) for common everyday events.
- **Group personal data with respect to conceptually coherent episodes** by means of **scripts**.
- **Extensible approach for implementing script instantiation** from PDTs.
  - Declarative description of scripts, evidence, clues, mappings
- **Evaluation** of our approach through a case study on **real-user** data.
- **Design of a mobile application with narrative views of users' digital memories.**

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THANK YOU!

ANY QUESTIONS?

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