Mobility Insights at Swisscom : Understanding Collective Mobility in Switzerland

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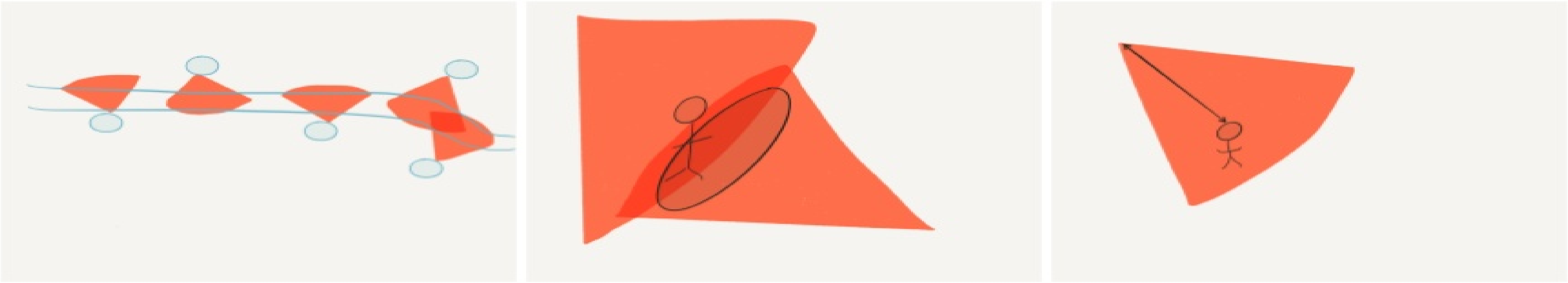
Agenda

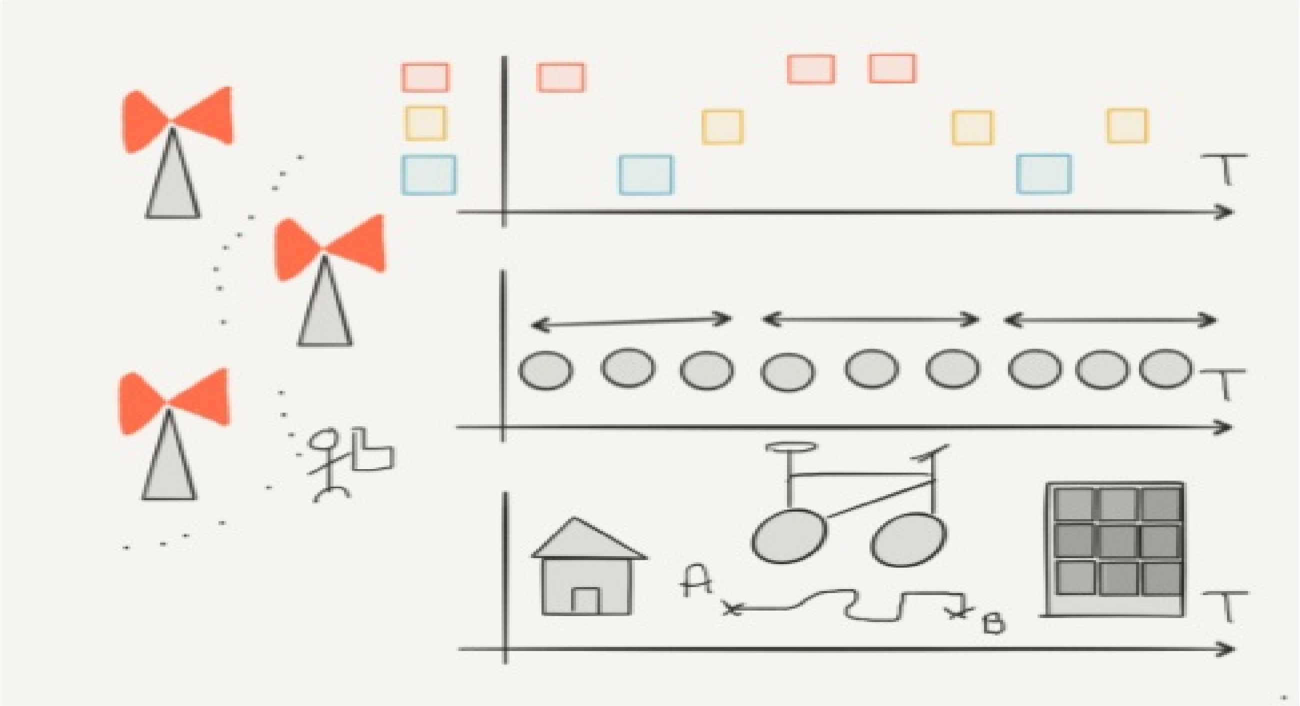
- Intro
- Smart-Data
- Big Data Architecture
- Trajectory Classification
- Streaming
- Data challenges

Introduction : Positioning

Positioning users in a modern network



- no triangulation at scale
- positioning based on cell attachement history, prec ~200m
- cell-to-cell handover, prec ~50m around limit
- Timing Advance (roundtrip) : better results on good data sources



Trajectory data mining

- time series reconstruction
- trajectory segmentation
- map matching, clustering
- mode of transport detection
- ...

How to create value with positioning at Swisscom ?

- with competitive analytics & data sources,
- and by making sure it embodies the right values.

Smart Data

On (not) tracking (any users)

"Swisscom strictly complies with all applicable legislations, in particular with the telecommunications law and the data protection initiative."

Jürg Studerus, Swisscom Senior Manager, Corporate Responsibility

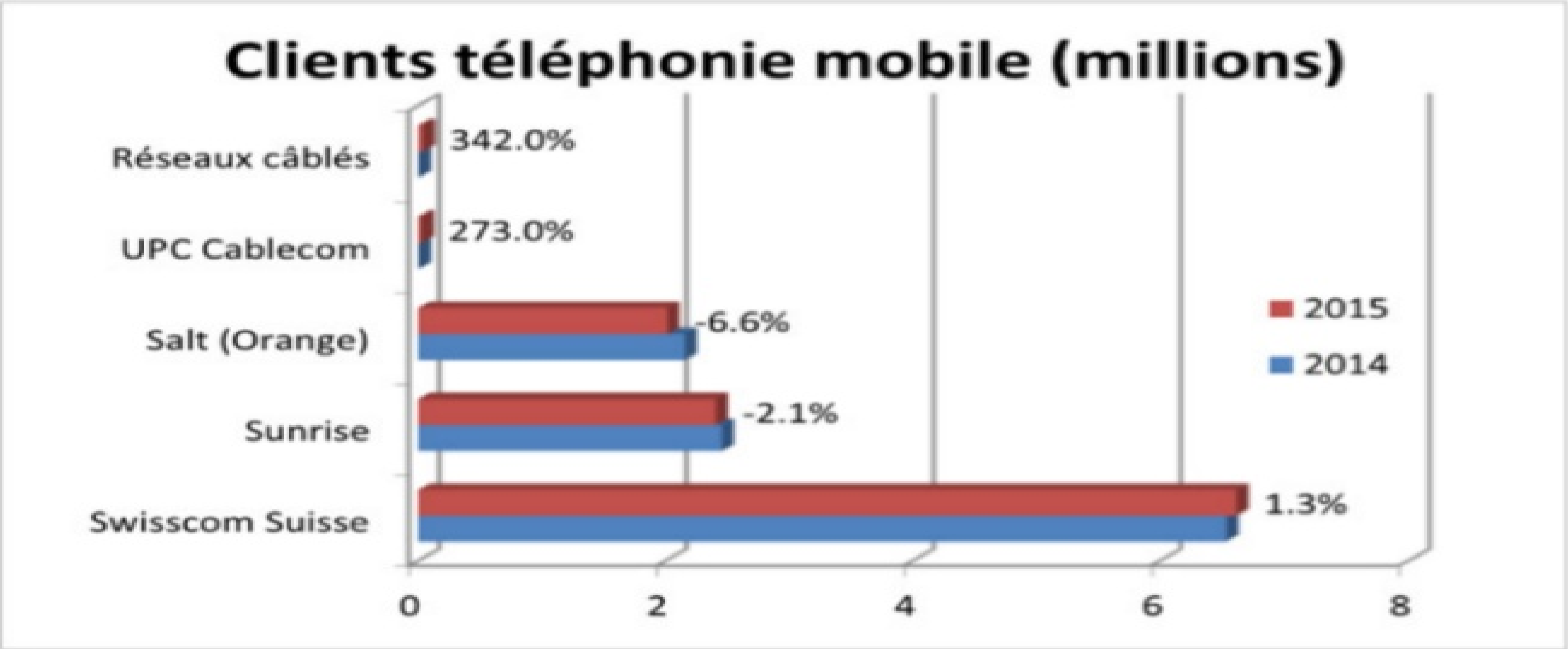
Smart Data : Big Data without Big Brother

- Privacy preservation is an asset
- It makes sense to care as much about your customer as they do about you.

We technically enforce this

- answering only synoptic questions, no individual ones,
- with data flow control : we neutralize quasi-identifiers at every stage

Swisscom mobile subscribers

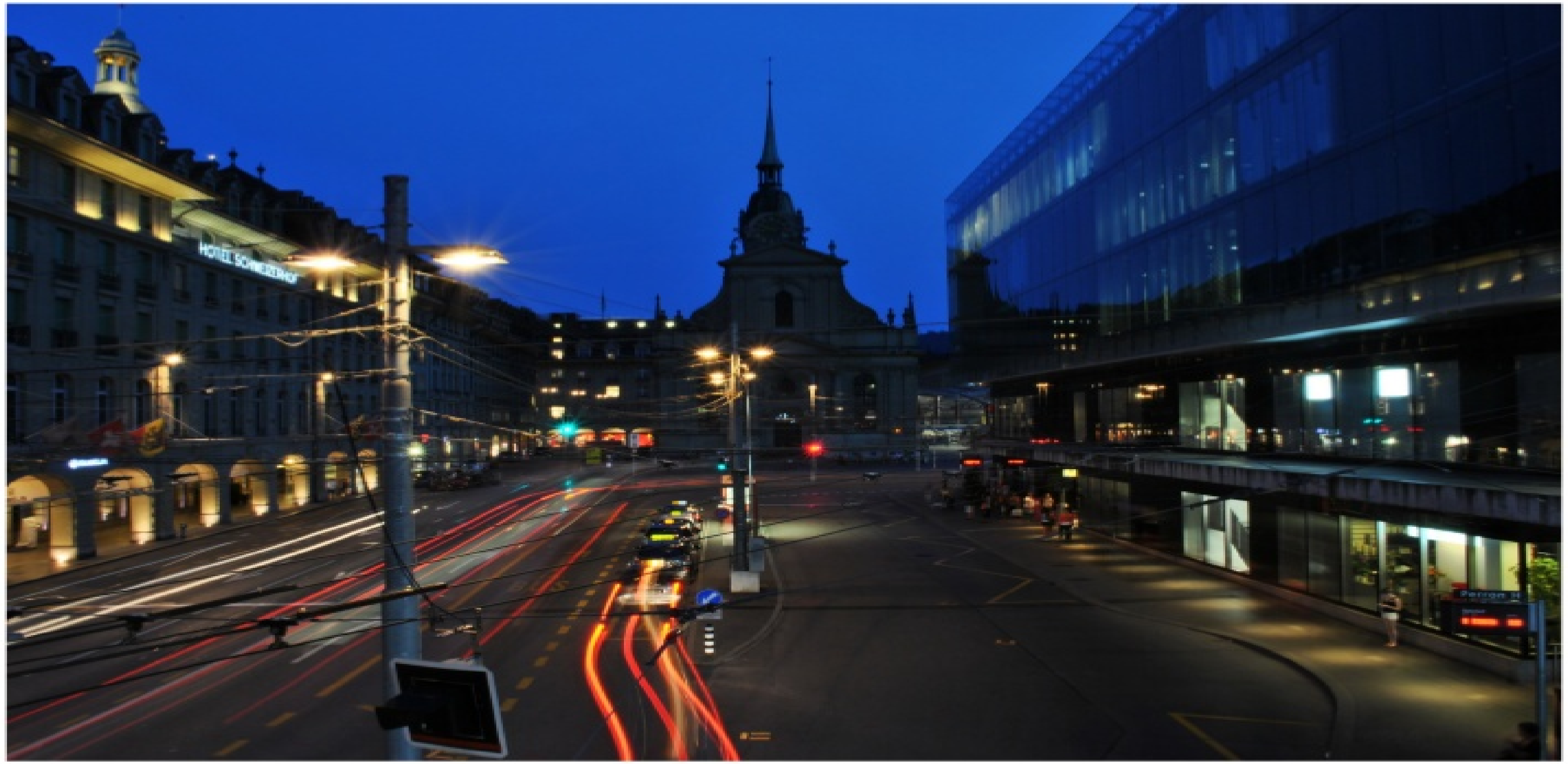


source: xavierstuder.com, MD&A reports

Our choices

- public good applications: making Switzerland run better,
- understanding places, not individuals,
- anonymized aggregations

A first product : City



"It's a dream for civil engineers" -- Alexandre Machu, Urban systems engineer, Pully

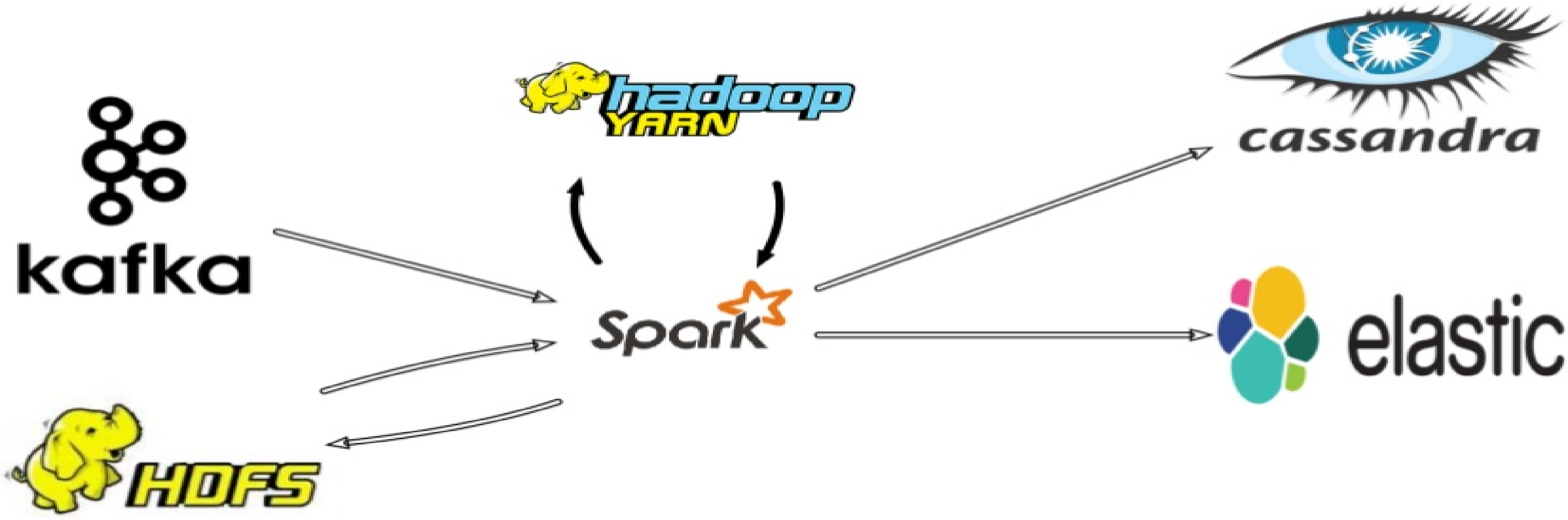
Demo time

Usages

- New roads to divert transit traffic out of downtown (informs a 50M$ project)
- Parking lot expansion and transformation (informs a 10M$ project)
- Electric car charging station deployment

Big Data architecture

In the backend



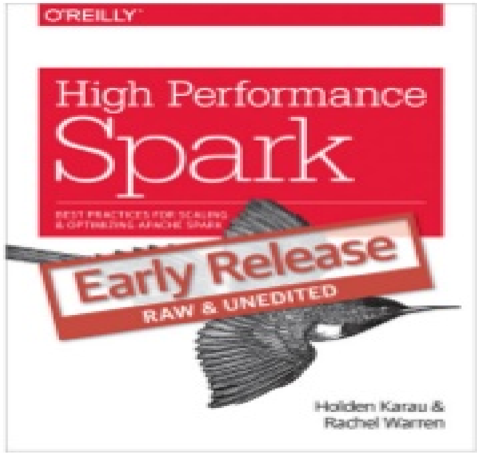
Spark configuration essentials for enterprise jobs

```
spark.executor.memory="not the default 1g"
spark.kryo.registrator="something custom" // among others

spark.shuffle.service.enabled="true"
spark.dynamicAllocation.enabled="true"

spark.deploy.recoveryMode="ZOOKEEPER"
spark.deploy.recoveryDirectory="/path/to/state"
spark.deploy.zookeeper.url="quorumMachine1:2181, ..."
```

NOT the only valuable settings, see
https://techsuppdiva.github.io



Scala (1/2)

```
type ChronoHistory = List[UEupdate] @@ Chronological
type AnteChronoHistory = List[UEupdate] @@ AnteChronological

implicit class Chrono(l: List[UEupdate]) {
  def asChrono: ChronoHistory = {
    chronoCheck(l)
    l.asInstanceOf[ChronoHistory]
  }
  def asAnteChrono: AnteChronoHistory = {
    anteChronoCheck(l)
    l.asInstanceOf[AnteChronoHistory]
  }
}
```

Scala (2/2)

```
implicit def reverseChrono(l: ChronoHistory): AnteChronoHistory
implicit def reverseAnteChrono(l: AnteChronoHistory): ChronoHis
```

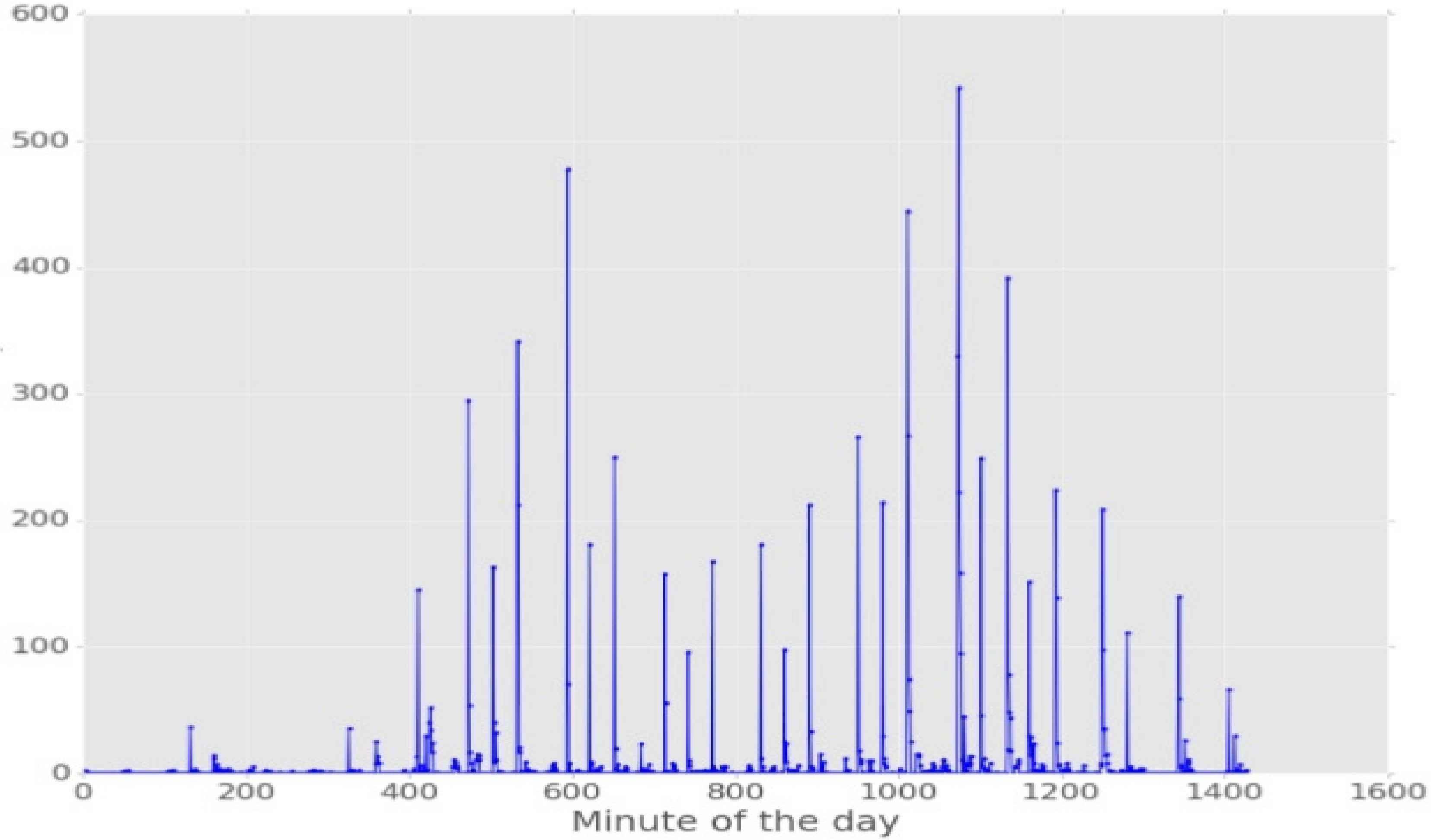
Trajectory Classification

What is the proportion of trips associated with trains?

Mode of Transport Detection

- **Input:** Sequence of network events
- **Output:** Mode of transport (train vs. other)
- Network events associated with cells
- Create fingerprints of cells
- **Intuition:** cells with intermittent increases in the number of connections are associated with collective mode of transports

Bursty Cell



Number of devices vs. minute of day

Burstiness

Random process with mean μ and variance σ^2, the relative variance is

$$D = \frac{\sigma^2}{\mu}.$$

Machine Learning with Spark

- Periodic Spark job to compute cell features
- Supervised training on labeled data (train vs. others)
- Training and test with Spark ML

Spark (1/2)

```
val labeledPoints: RDD[LabeledPoint] = data.map {
  case (transportMode, tripFeatures) =>
    LabeledPoint(
      labelOf(transportMode).toDouble,
      featuresToFeatureVector(tripFeatures)
    )
} // generate labeled data
labeledPoints.cache()

def trainNewModel = // Fix the used model
  new LogisticRegressionWithLBFGS()
  .setIntercept(true)
  .setNumClasses(numberOfClasses)
  .run(_: RDD[LabeledPoint])
```

Spark (2/2)

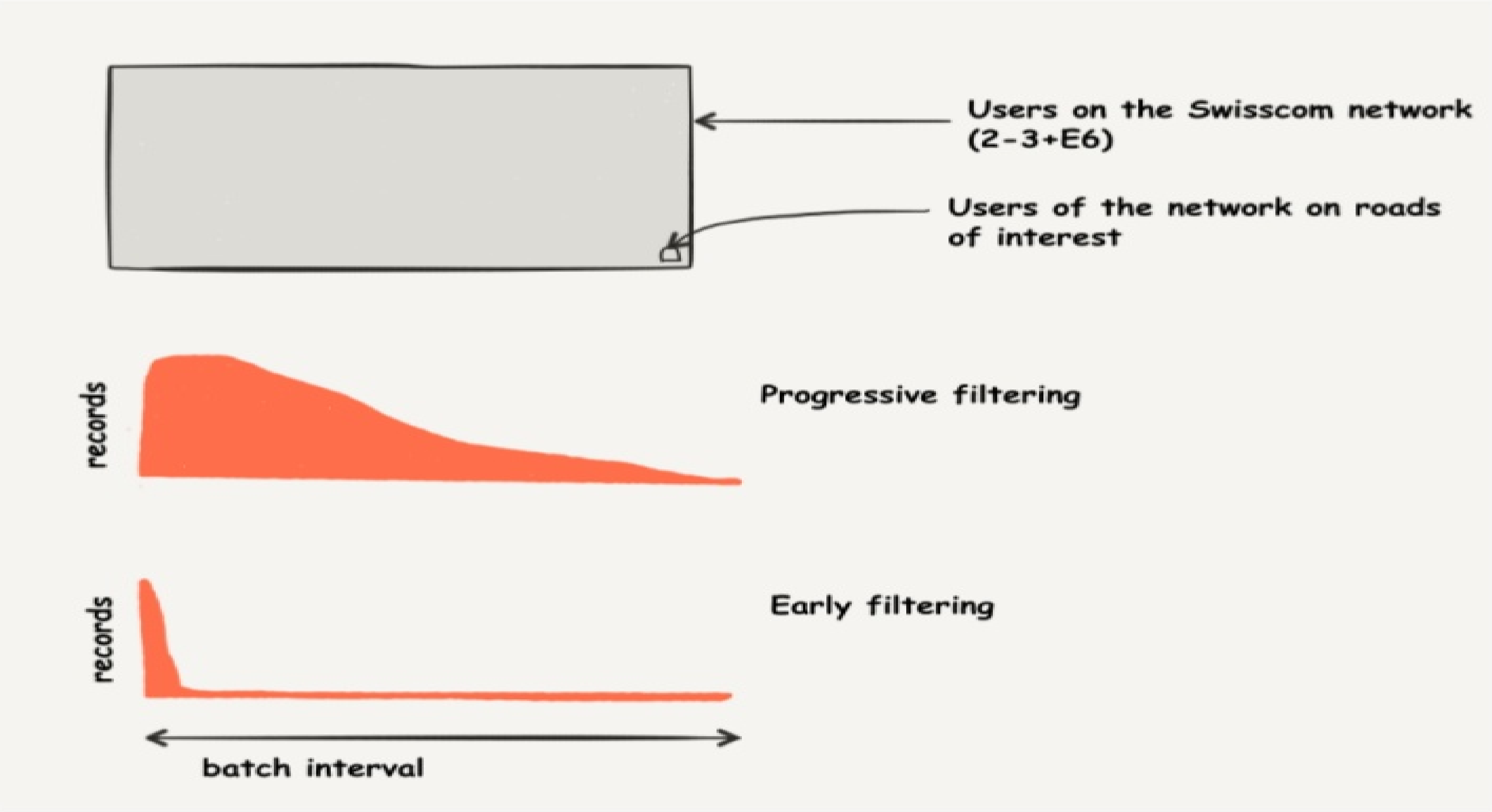
```
// train a model for performance evaluation
val model = trainNewModel(trainingData)

// Evaluate model on test instances and compute test error
val labelAndPreds = testData.map { point =>
  val prediction = model.predict(point.features)
  (point.label, prediction)
}
val testErr =
  (labelAndPreds
    .filter(r => r._1 != r._2)
    .count().toDouble) / testData.count()
// train final model on the whole dataset
val finalModel = trainNewModel(labeledPoints)
```

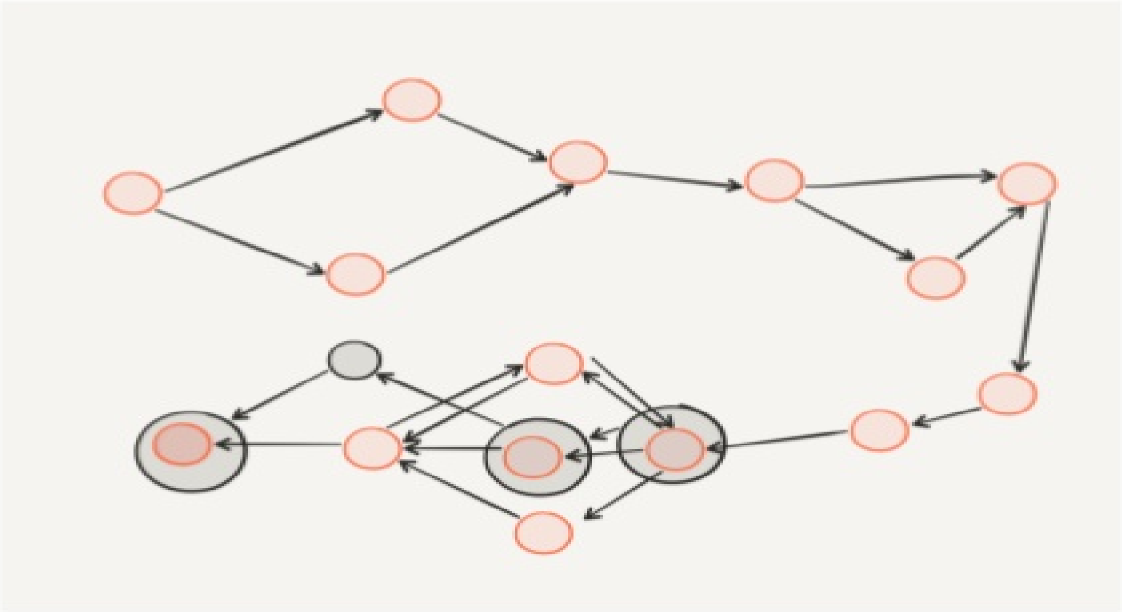
Streaming Analytics

Road conditions on highways

Selecting users on a path of Interest



Graph matching



Locality-sensitive hashing :

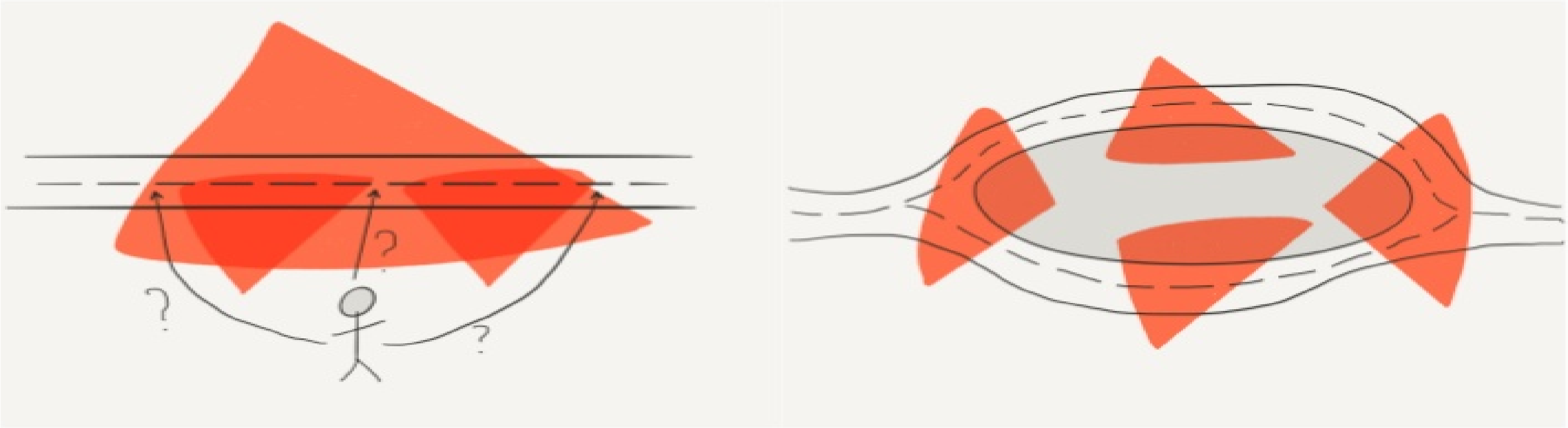
A **family** H of hashing functions is (r, cr, p_1, p_2)-sensitive if:

- if $p - q \leq r$ then $Pr_H[h(q) = h(p)] \geq p_1$
- if $p - q \geq cr$ then $Pr_H[h(q) = h(p)] \leq p_2$

More:

- *Locality Sensitive Hashing By Spark*, Uber, Spark Summit 2016
- *A Gentle Introduction to Locality-Sensitive Hashing with Apache Spark*, Scala By The Bay 2015

Computing speeds: Solving graph constraints



- given a history of cells, where was the user, exactly ? (twice)
- what's the path between 2 positions ?
- linear query **per user**

Checkpointing: Set the checkpoint interval

- are you checkpointing too often ?
- every k batches, you'll need p batches to recover from checkpointing time loss
- make sure $k \geq p$

Data Challenges

Crucial elements

- Quality, reliability of data sources
- Automated ground truth checking
    - sensors
    - TEMS fleet
- What's the ground truth for mode of transport, domicile, etc ?
- Colleagues and friends volunteers

Questions ?