Presence-based Availability and P2P Systems

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What this talk is about

- We introduce a new metric for computing object availability in P2P systems
- We show why this metric is better than existing method
- We show why it matters

Outline

- Motivation and Problem
- Metrics
- Evaluation
- Conclusions

Availability 101

- *Object availability* in P2P systems
  - How often are object requests successful?
  - It depends on:

    1. The *number* of peers holding object
    2. The *availability* of those peers

- Want to map these two factors to object availability

Why do we care about availability?

- We want to compare the reliability and availability of different P2P architectures
  - Use in *offline* manner to guide algorithm choice

- We want to design highly available P2P systems
  - Use *online* as part of algorithm.
  - Need to know object availability so we can adjust other factors on-the-fly
    - e.g., creating new replicas

The old world: distributed services

- An object is replicated on a set of N servers
  - Servers are centrally managed, failures are rare
  - Operational assumptions:
    i. Servers **fail independently**
    ii. All servers have **similar uptimes**
- Object availability is simple to compute
  - is the probability that at least one server is up

  = 1 - (1 - mean uptime of servers)^N

The new world: P2P systems

- An object is held by a set of N peers
  - No central management, peers are often disconnected
  - Replication may not be managed
  - Operational realities:
    i. Peers' downtimes are **not independent** -- peers prefer being online at certain times of day
    ii. Peers have very **different uptimes**

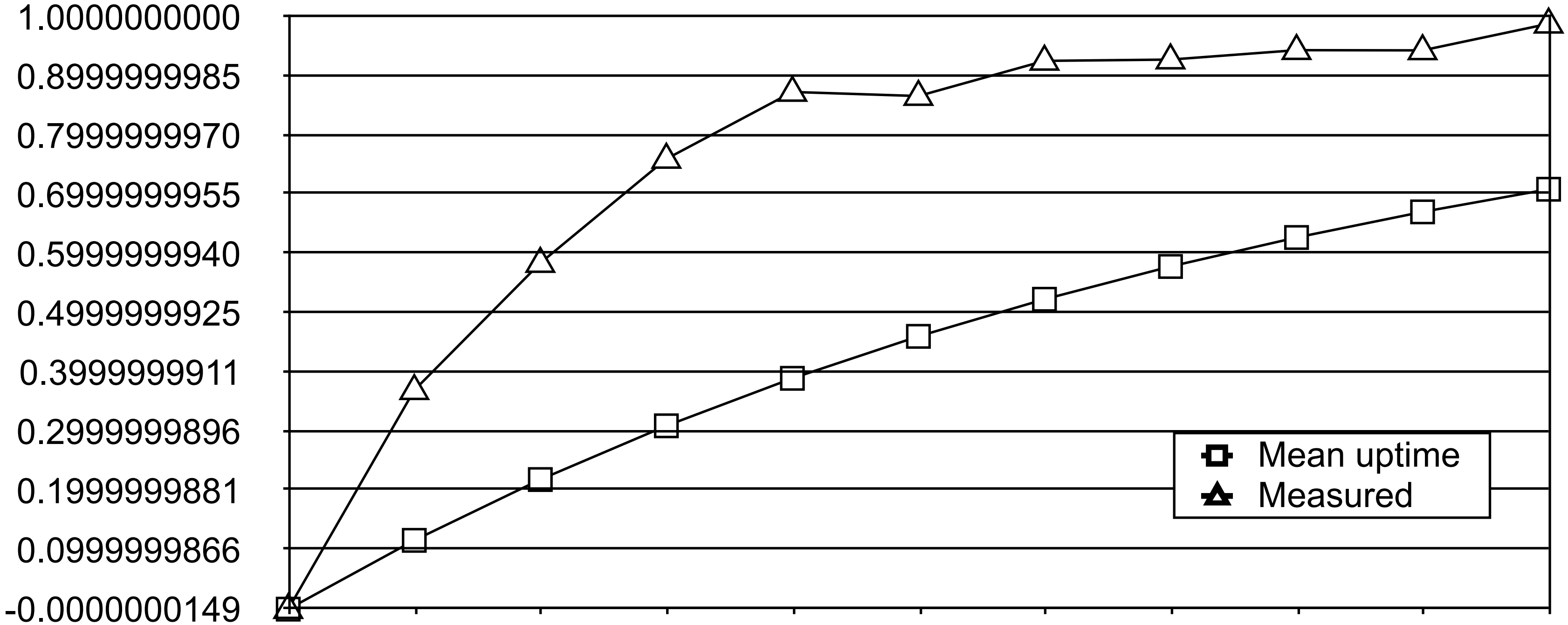
- Object availability is harder to compute
  - Mean uptime is not useful given these realities

Example

- System 1
  - 24 peers
  - Each peer up a different hour of the day
- System 2
  - 24 peers
  - All peers up the same hour of the day

- Both systems have the same mean uptime
  - but they provide very different object availability!

Data



- Using mean uptime underestimates object availability

Outline

- Motivation and Problem
- Metrics
  - Mean uptime
  - Presence-based
- Evaluation
- Conclusions

Current metric

- Suppose object on *n* peers, need *k* for service (usually 1)
- Probability of one peer up:
  - Calculate uptime of each peer
  - Take mean and use as prob. for each peer (*mean uptime*)
- Object availability = probability that *k* of *n* peers up

New metric: Presence-based availability

- Changes to probability based on distribution
- Weighted uptime (presence)
  - Uptime of peer (or set of peers) weighted by how many *other* peers are up
  - Accounts for more requests during those times
- Probability different for each set
  - Object can be on any set of n peers
  - Weight each set by probability it is the set with the object

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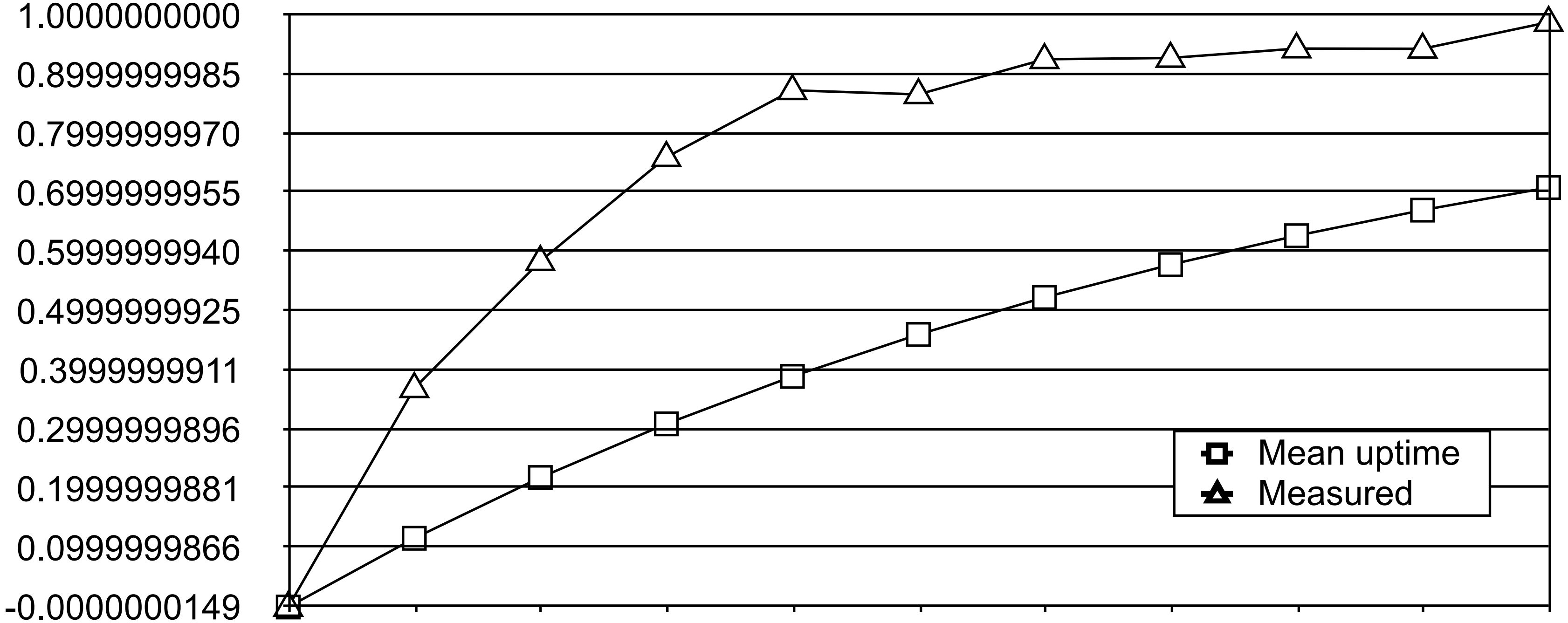
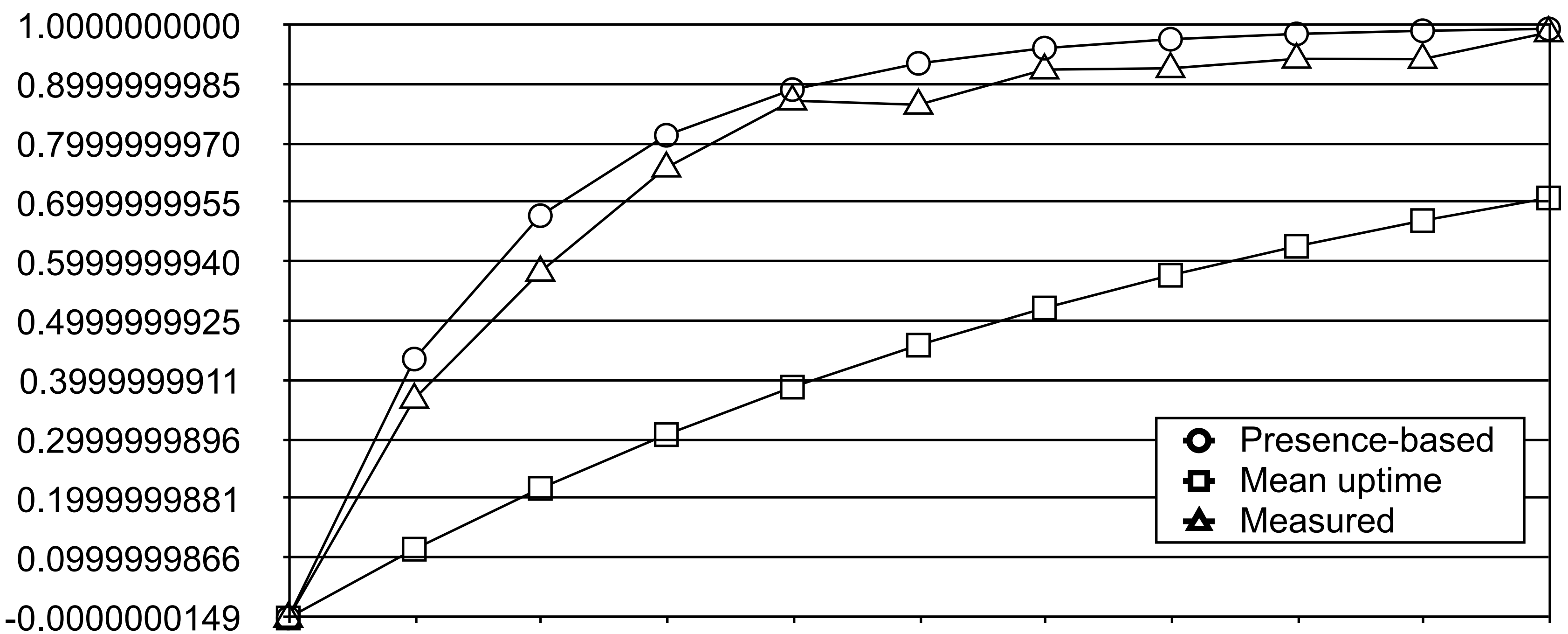
Comparison with measured availability

- Trace of availability/requests from existing P2P system (Kazaa) drives simulation
- For each request:
  - Calculate number of copies in existence
  - Mark if successful
- Find average success rate given *n* copies
- Compare to predicted values (mean uptime vs. presence-based)

Prediction vs. measured availability



Prediction vs. measured availability



- Presence-based much closer to measured

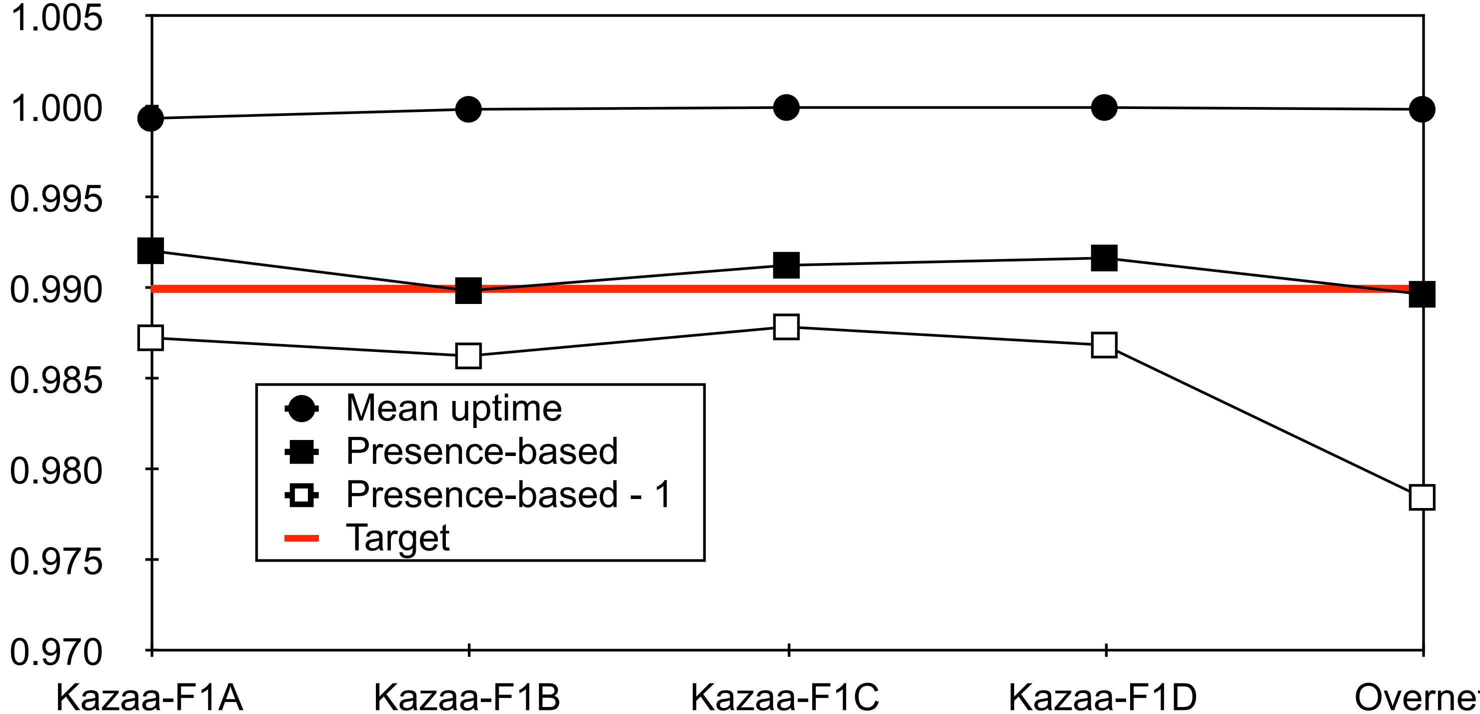
Using availability prediction

- Can use more copies to increase availability
- How many copies to achieve availability x?
- Inverse of prediction function
- In practice:
  - Continuously monitor number of copies
  - Replicate as necessary to maintain minimum
- Overhead is cost of replication

Comparison with existing system

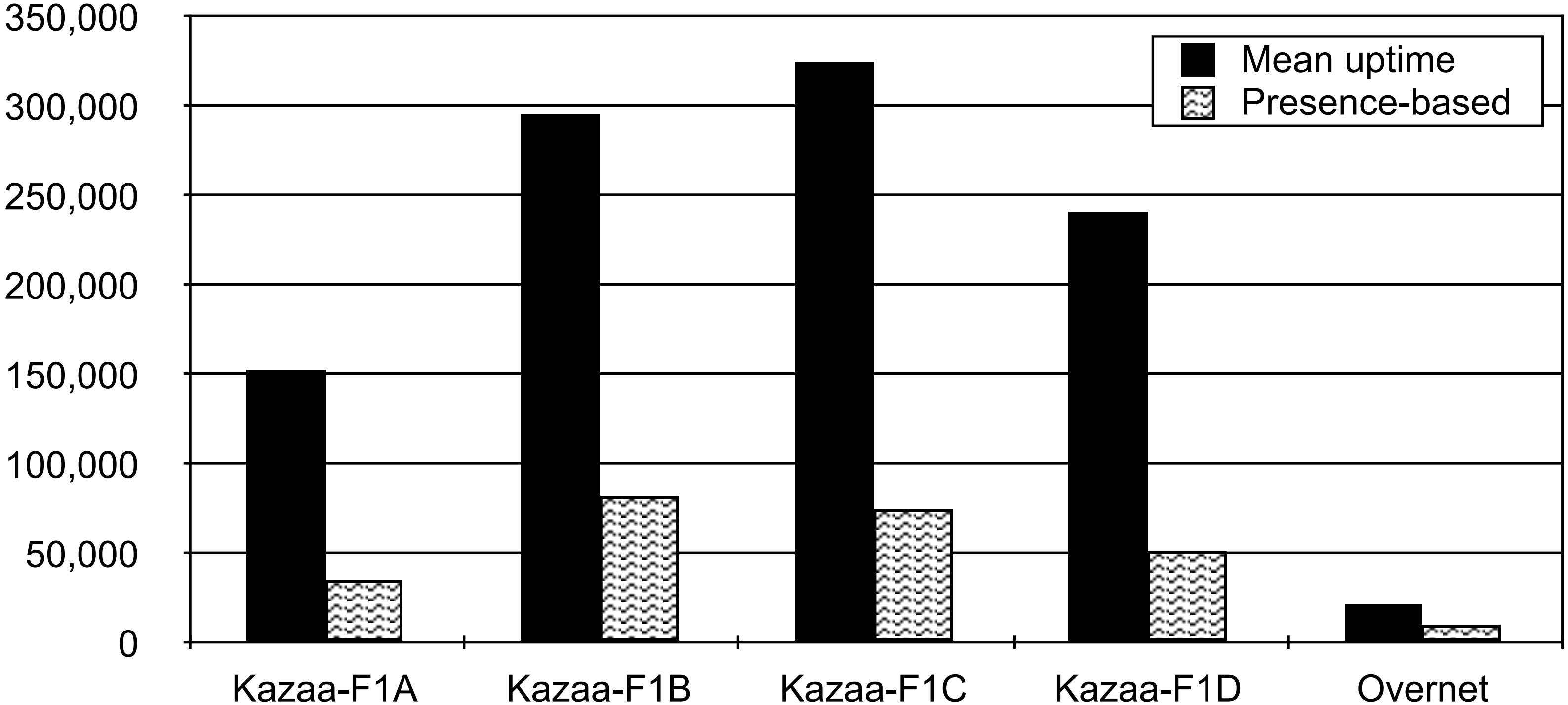
- Total Recall
  - Implements above strategy using mean uptime
- Overestimates number of copies
  - Unnecessarily high availability
  - Result: higher overhead
- Our prediction closer to the truth

Achieved availability



- Our prediction closer to target availability

Reduction in transfers



- Our prediction introduces lower overhead

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Conclusions

- Object availability traditionally predicted using mean uptime
- This fails for common peer workload
- Solution: presence-based availability
- Results:
  - More closely predicts measured availability
  - Used as a parameter, achieves more correct results with lower overhead

Presence-based prediction

- *Presence* is the weighted uptime of a set
- Weights proportional to uptime of set

$$A^{<k,n>} \equiv \frac{\sum_{S} uptime_S \bullet presence_S}{\sum_{S} uptime_S}$$

- Accounts for time-of-day and differing uptimes

Background

- Consider a P2P storage system
  - Peers with differing availabilities (uptime)
  - Requests to objects stored on these peers
- Performance based on request success
- Success based on *object availability*
  - Probability over time that a peer with the object is available
  - Depends on peer availability and number of copies

The Problem

- Know peer availability
- Want to *predict* object availability
  - Function of peer uptimes and number of copies
  - Result is estimated object availability
- Uses:
  - Comparing two peer workloads
  - Predicting performance of system for tuning

Formal statement

- Consider a single object
- N peers, of which n have copy of object
- Uptimes of peers over interval T
- Need k copies (typically 1) for success
- Given uptimes, what is the probability we can get object over all sets of n peers?
  - Object availability = F(k,n,uptimes)

The old world: distributed services

- An object is replicated on a set of servers
- Servers are centrally managed
- Failures are rare
- Each server has an independent uptime
- A request is successful if one server with the object is up
- Availability is simple to compute
  - Use mean uptime averaged over servers

The new world: P2P systems

- An object is held by a set of peers
- No central management
- Peers may be unreliable, disconnection is common
- Replication is unplanned and random
- Uptimes not independent (e.g., may be time dependent)
- Availability is difficult to compute
  – Mean uptime has no meaning over (very) heterogeneous peers

Traditional measure

- Calculate uptime % (U) for each peer
- Take mean uptime as proxy for peer availability
- Object availability is probability that k of n peers are up, all with probability U

$$U^{<k,n>} \equiv \sum_{j=k}^{n} \binom{n}{j} U^{j} (1-U)^{n-j}$$

Problems with mean uptime

- Fails to account for two properties of P2P peers
- Peers prefer particular time of day
  - More peers up at particular time → higher object availability
- Peers have unequal uptimes
  - Object on high-uptime peers → higher availability (and vice versa)
- In general, underestimates availability

Presence-based availability

- Presence-based availability of set *S*:
  - Consider times when *S* is available and not (*k* peers up or not)
  - Weight each by number of *other* peers up at the time
  - Fraction is *presence* of set
- Maximum when *S* is up at all times others are up