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Trust and Reputation Systems

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Audun Jøsang, UiO/UNIK – QUT
http://persons.unik.no/josang/

This presentation

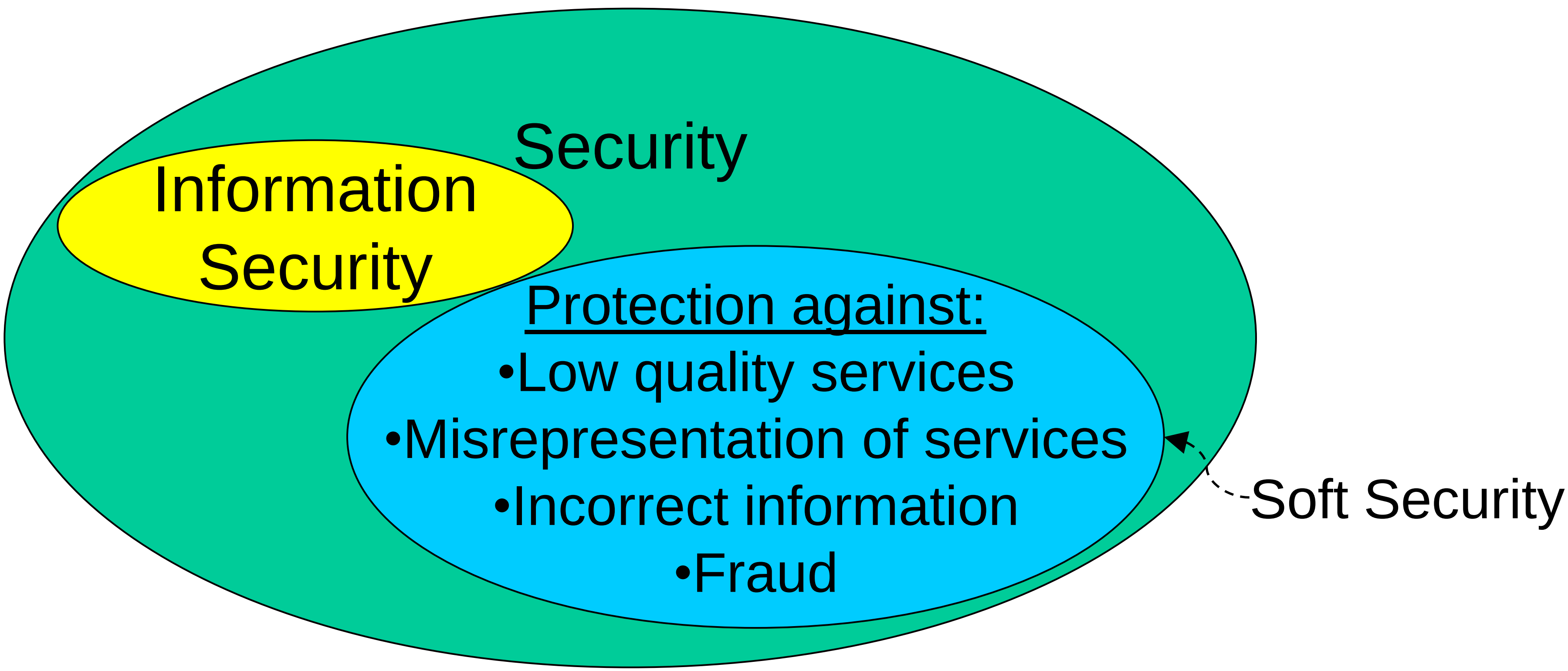
- Trust and Security
- Trust classes and trust semantics
- Principles for building trust and reputation systems
  - Network architectures
  - Computation engines
- Commercial and online systems
- Problems and proposed solutions
- Concluding remarks

Soft security and basic trust concepts

What is Security?

- General definition of security:
  - *Protection from danger*
  - Oxford English Online Dictionary: http://dictionary.oed.com/
- Traditional definition of information security:
  - *Preservation of confidentiality, integrity & availability of information*
  - ISO/IEC 27001:2005 Specification for an Information Security Management System
  - Assumes that the owner of information resources
    - defines a security policy (explicitly or implicitly)
    - implements measures to preserves CIA properties

Gap analysis of security and information security



Soft Security

- Impossible to define security policies for open communities
- Common ethical norms instead of security policy
  - Can be partly formal and partly dynamic/collaborative
- Definition:
  - ***Adherence to common (ethical) norms***
- Stimulates the quality of communities in terms of ethical behaviour and integrity of its members
- Enforced by collaborative mechanisms such as trust and reputation systems

Two definitions of trust

- Evaluation trust
  - The **subjective probability** by which an individual, *A*, expects that another individual, *B*, performs a given action on which its welfare depends. (Gambetta 1988)

- Decision trust
  - The **willingness to depend** on something or somebody in a given situation with a feeling of relative security, even though negative consequences are possible. (McKnight & Chervany 1996)

Would you trust this rope?

For what?

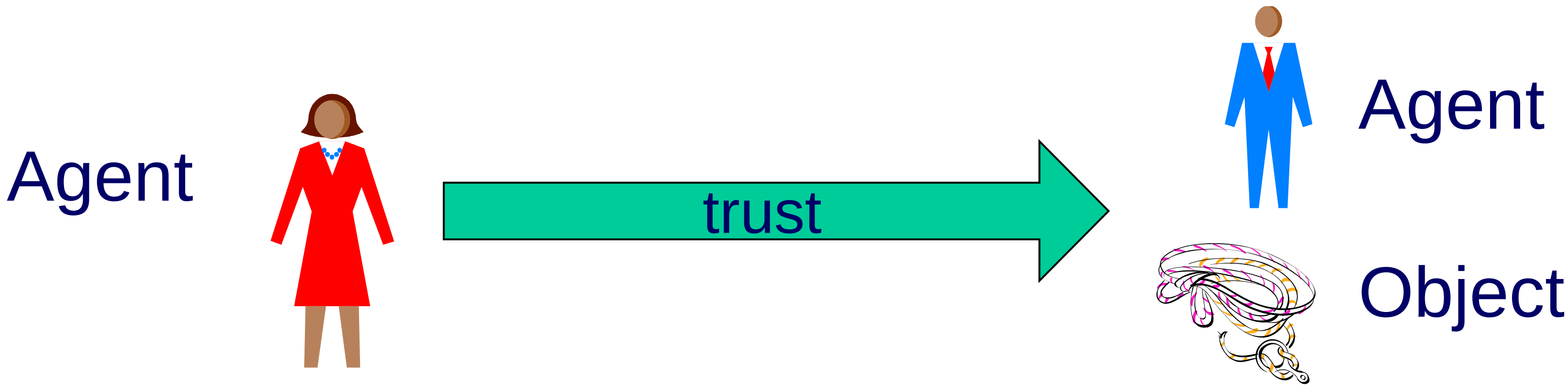
To climb down from the 3rd floor window of a house

The rope looks very old

Fire drill: **No!**

Real fire: **Yes!**

Trust is a relationship



- Trusting party
  - Also called
    - “relying party”
    - “trustor”
  - Is in a situation of
    - Dependence
- Trusted party
  - Also called
    - “trustee”
  - Is in a situation of
    - Power
    - Expectation to deliver

Two sides of trust management

Trusting party

Wants to **assess** and make **decisions** w.r.t. the dependability of the trusted party for a given transaction and context

Trusted party

Wants to **represent** and put in a **positive light** own competence, honesty, reliability and quality of service.

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An interpretation of reputation

- Reputation is what is generally said or believed about a person's or thing's character or standing. (Concise Oxford Dictionary)
  - (Reputation of *B*)= Average[Reliability Trust in *B*]

- Reputation is public.
- Reputation is communicated by people who don't necessarily adopt it.

Reputation and trust

REPUTATION

- Public info
- Common opinion
- Not necessarily objective

TRUST

- Both private and public info
- Private info carries more weight
- Subjective

- *"I trust you because of your good reputation"*
- *"I trust you despite your bad reputation"*

Extrinsic and intrinsic trust

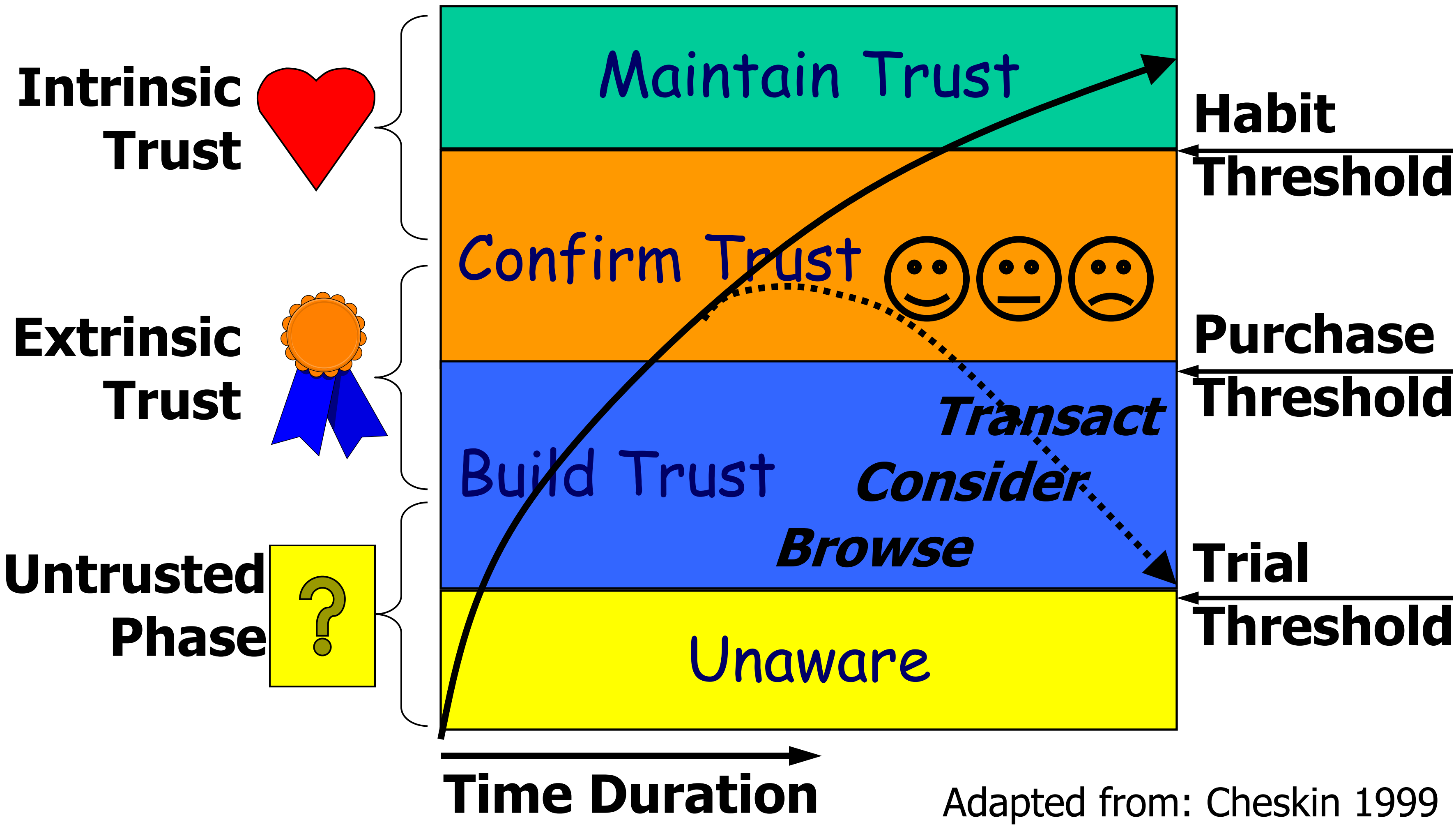
Extrinsic Factors

- Cognitive
- Observed
- Recommendation
- Reputation
- External evidence
- Easy to fabricate

Intrinsic Factors

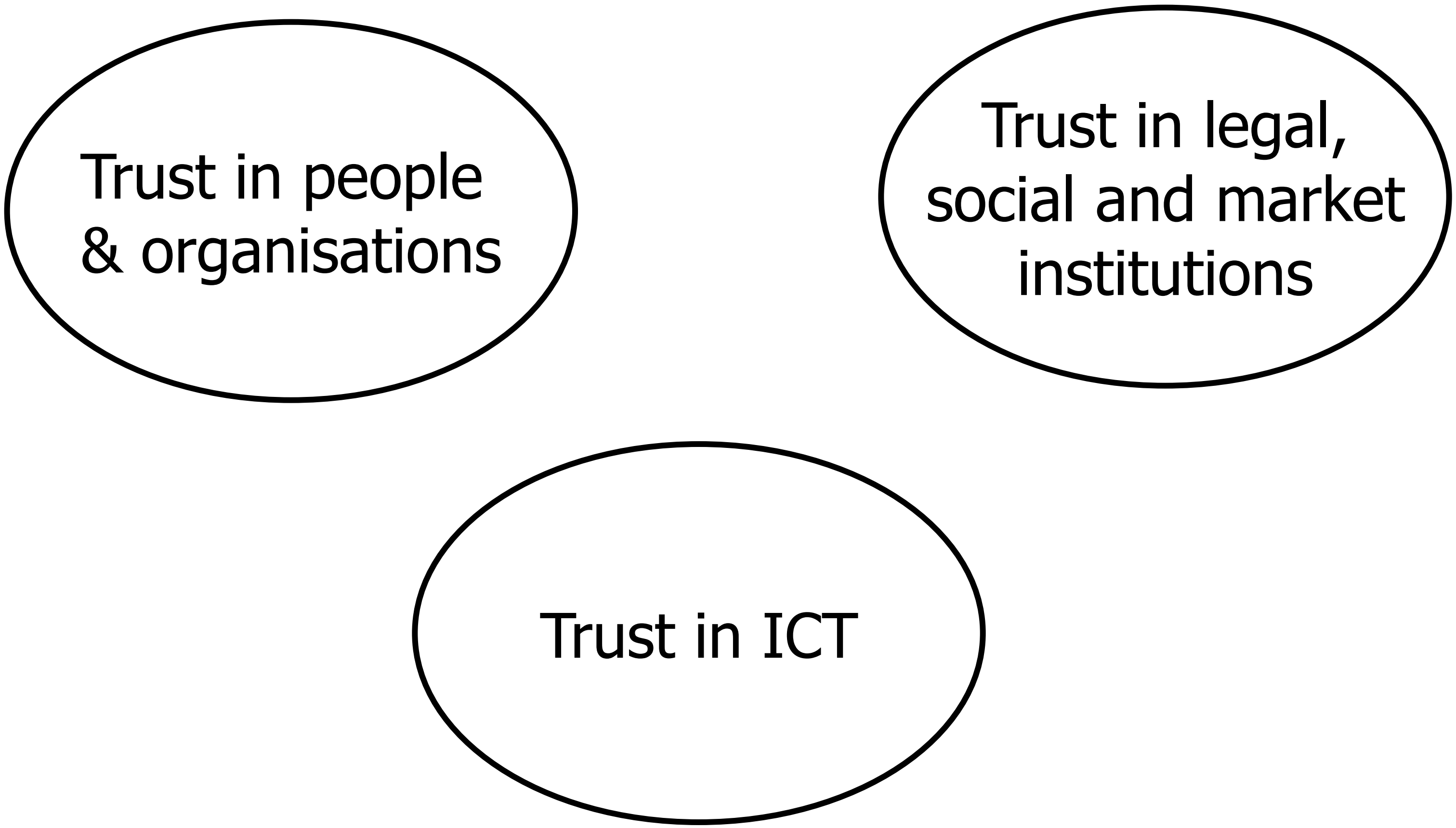
- Affective
- Experienced
- Intimate relationship
- Internalised pattern
- Take time to build
- Override extrinsic

A model for e-commerce trust

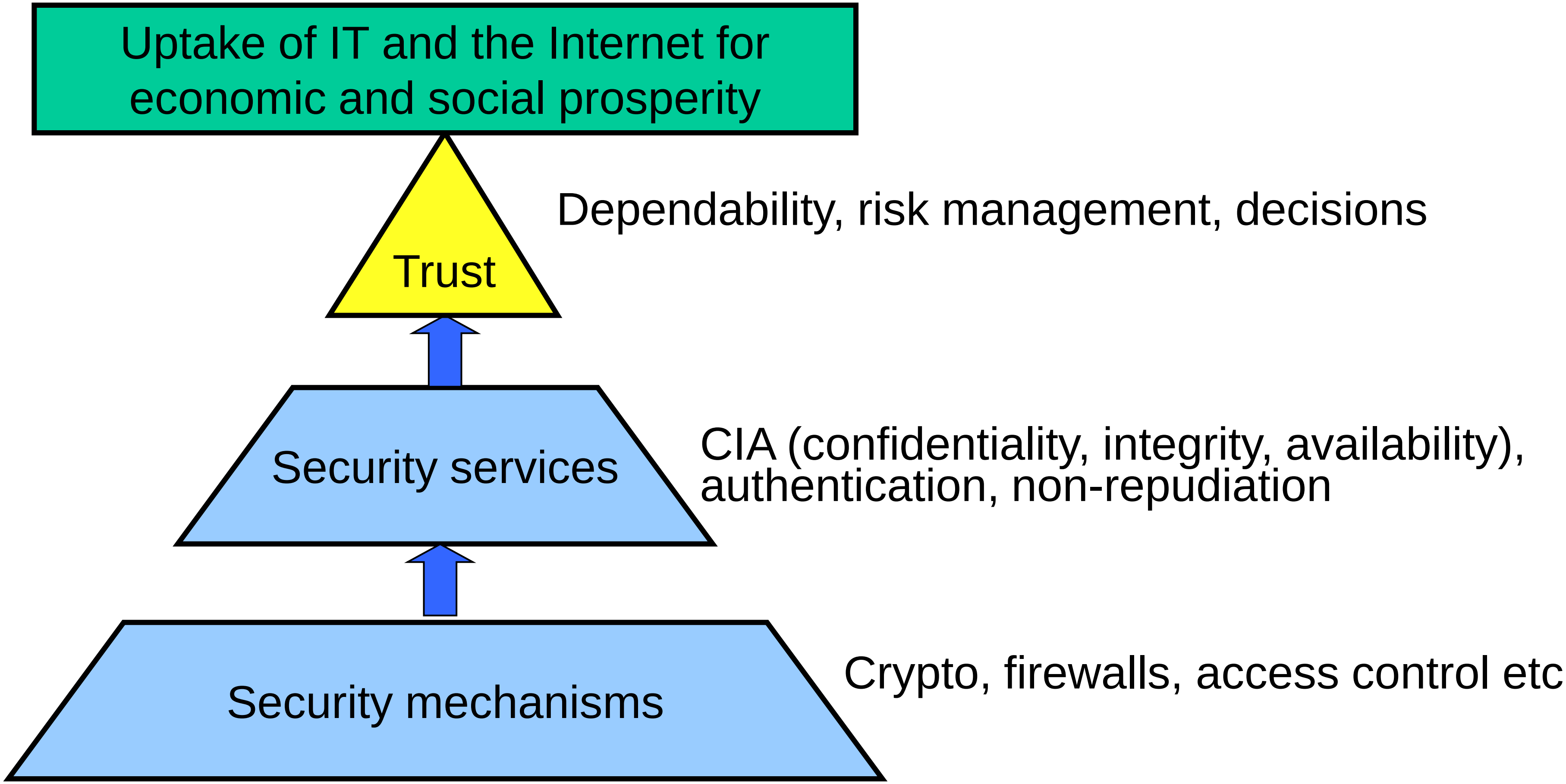


Adapted from: Cheskin 1999

We trust what we depend on



Trust as an abstract security layer



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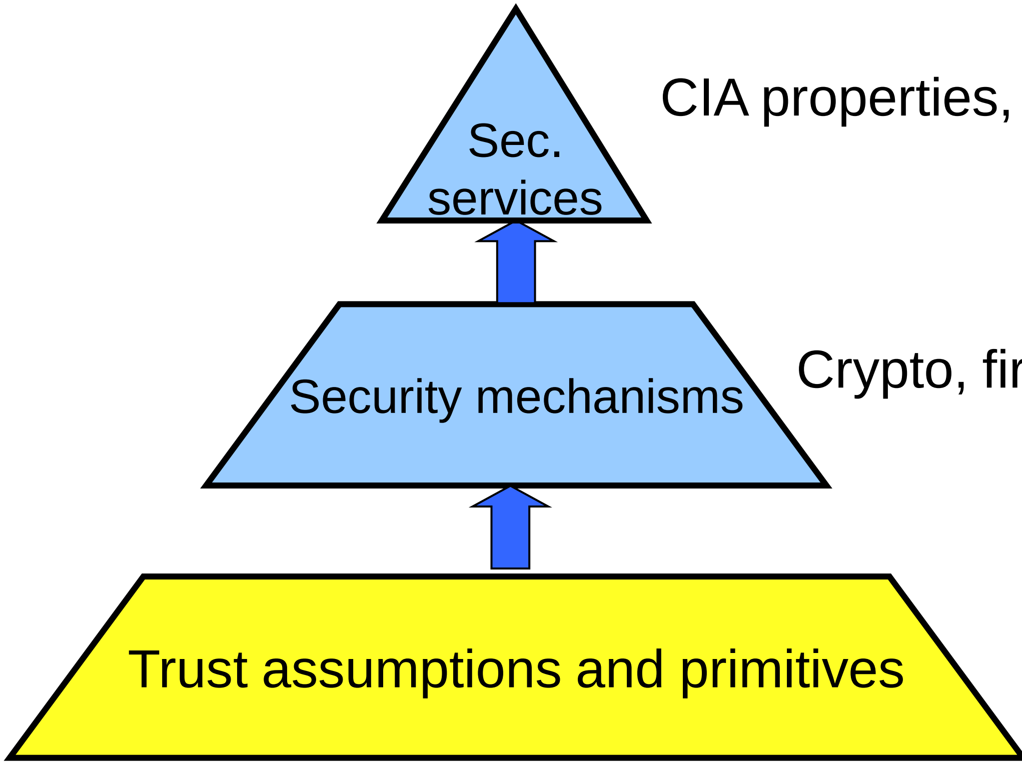
Trust as assumptions and primitives



CIA properties, authentication, non-repudiation

Crypto, firewalls, access control etc.

- Algorithm strength
- Password confidentiality
- Platform security
- Certificates and credentials
- Tokens and attributes

Why is the term “trust” so popular?

- Metaphorical trust expressions
  - IT security people like metaphors:
    - E.g. firewall, honeypot, virus, Trojan horse, digital signature
  - Trust expressions serve as simple metaphors for complex security concepts, e,g. , …, ***trusted code, circle of trust***, …
- Trust has very positive connotations
  - Trust expressions are ideal as marketing slogans

Trust expressions are difficult to intuitively understand

Trust Expressions in IT security

Trust management
Trustworthy computing
Trusted code
Trust bar
Trust anchor
Trust ecology
Trusted Computing Base
Trust system
Trusted system
Trusted computing
Trusted Platform Module
Computational trust
Trust negotiation
Trust model
Trust provider
Circle of trust
Trusted Third Party
Trust metric
End-to-end trust

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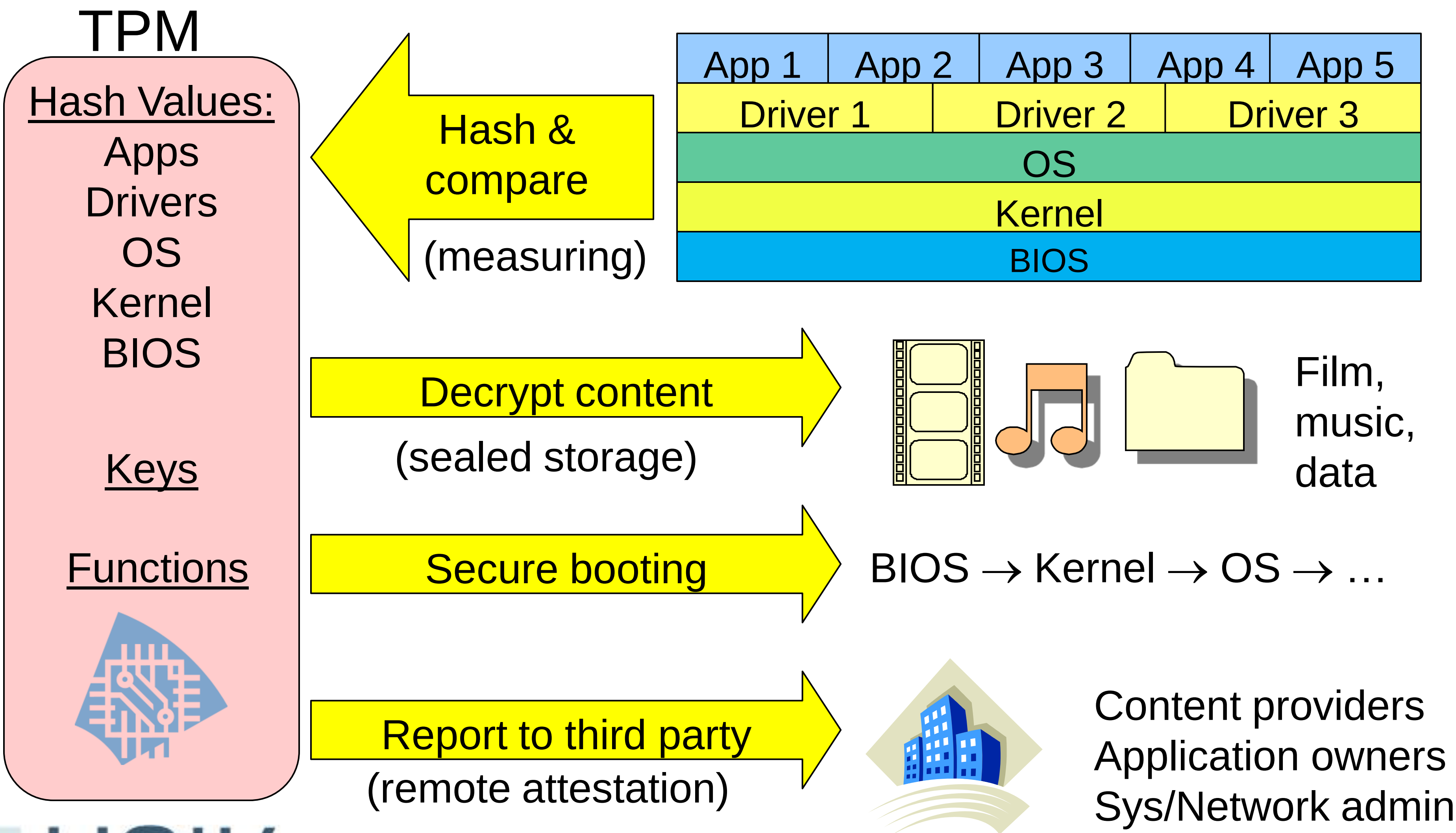
Trust management and access control

- Idea: “Who can I trust to access my resources?”
- Trusted user = authorized user
- Trusted code = code running as system
- Untrusted code = code running in a sandbox
- Access credentials can be exchanged and evaluated mechanically $\Rightarrow$ trust negotiation
- Access authorization can be delegated in a transitive fashion $\Rightarrow$ transitive trust

Trusted Computing

- Idea: Software can't be trusted, hardware can
  - Current paradigm: Security rooted software
  - TC paradigm: Security rooted in hardware
- 1999: Trusted Computing Group (TCG)
  - Trusted Platform Module (TPM) specification
- 2001: Production of TPM chip
- 2002: Microsoft announces Palladium platform
  - 2005: Next Generation Secure Computing Base (NGSCB)
- 2006: Limited trusted computing in Vista
  - Disk encryption based on TPM (trusted platform module)
- 2009: TPM in almost all PCs, not yet in mobiles

Trusted Computing *à la* TPM



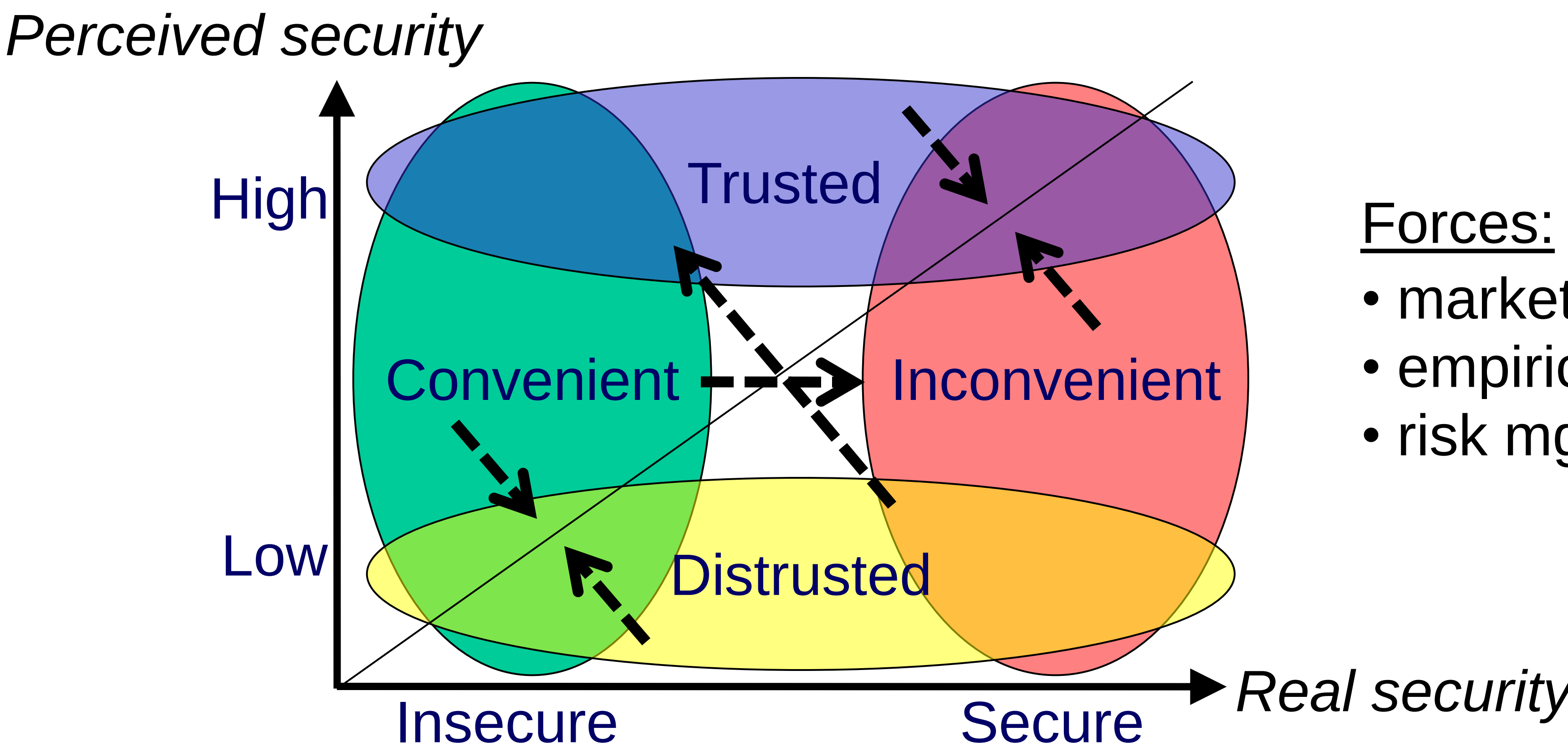
What trusted computing can do

- Can
  - Prevent booting with tampered software
  - Support identification and authentication of computer
  - Prevent unauthorized processing of content (DRM)

> If you want to do DRM on a PC, you need to treat the user as the enemy.
>
> Roger Needham
>
> Former director, Microsoft Research Europe

- Limitation
  - Requires static software so hashes don't change
  - Can not prevent changes of software in RAM

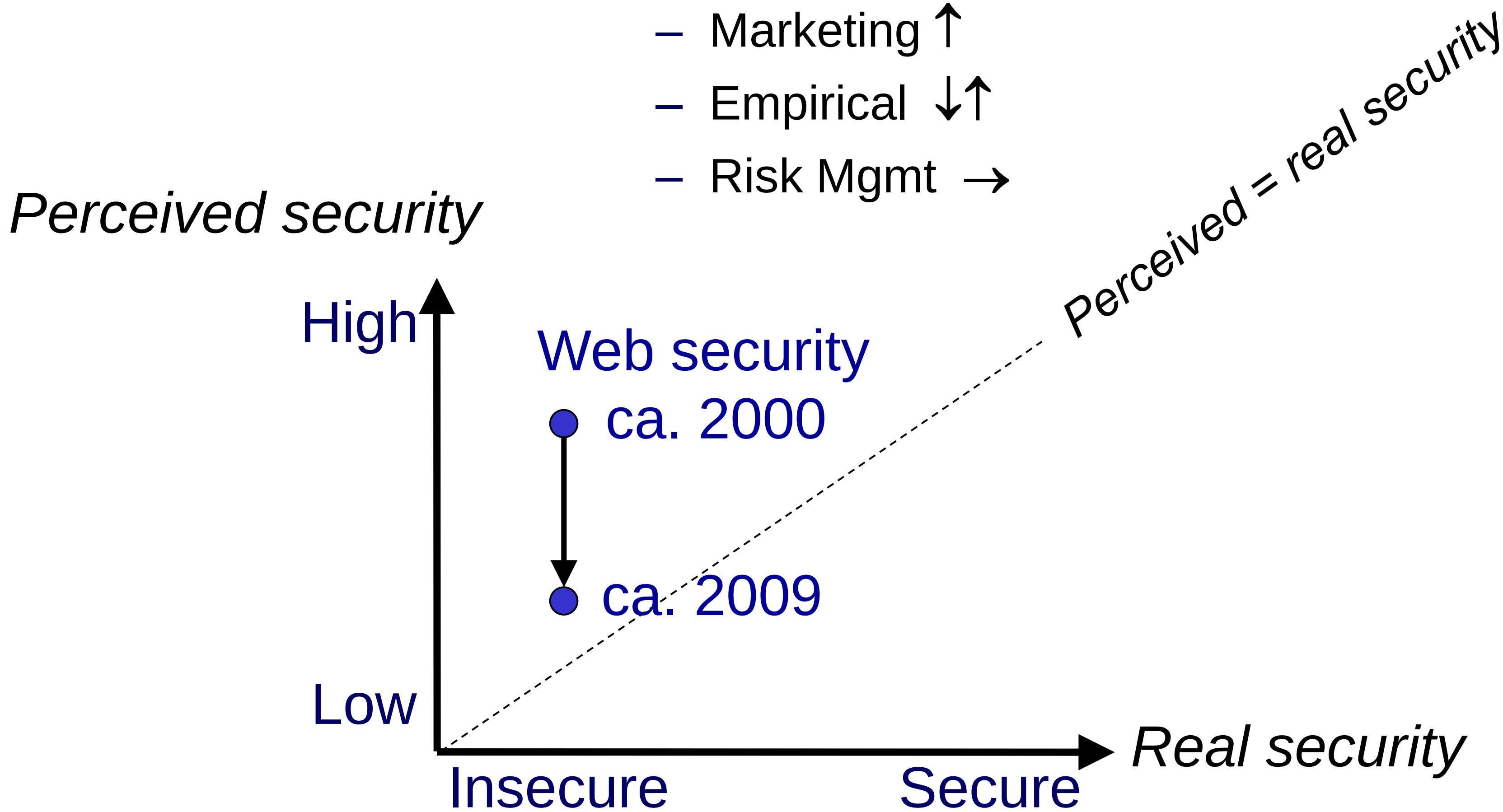
Perception and reality;
The subjective perspective



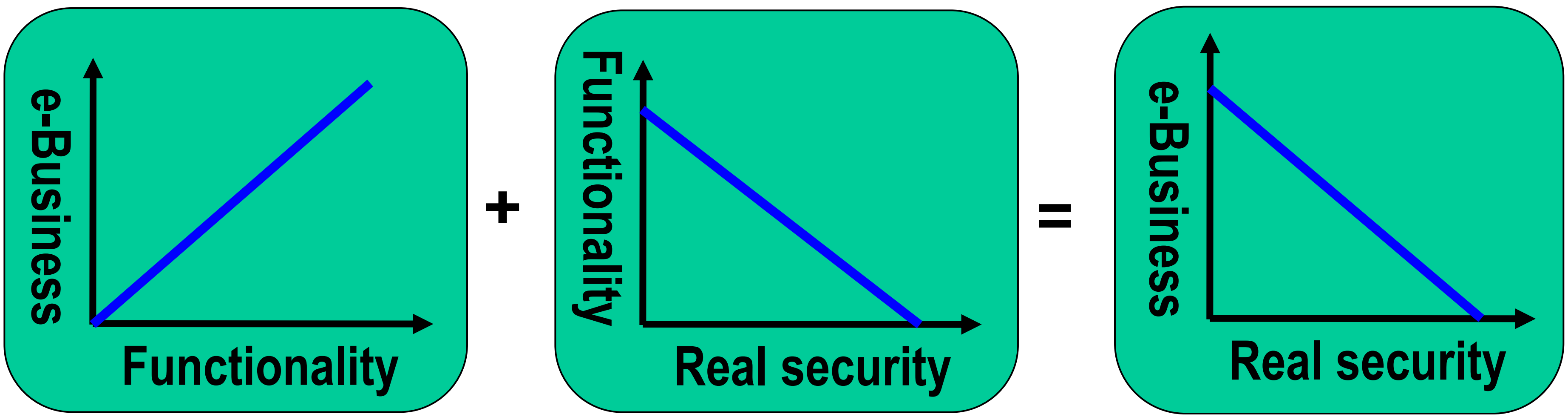
Forces:
- marketing
- empirical
- risk mgmt

Real and perceived security

- Opposing forces
  - Marketing ↑
  - Empirical ↓↑
  - Risk Mgmt →

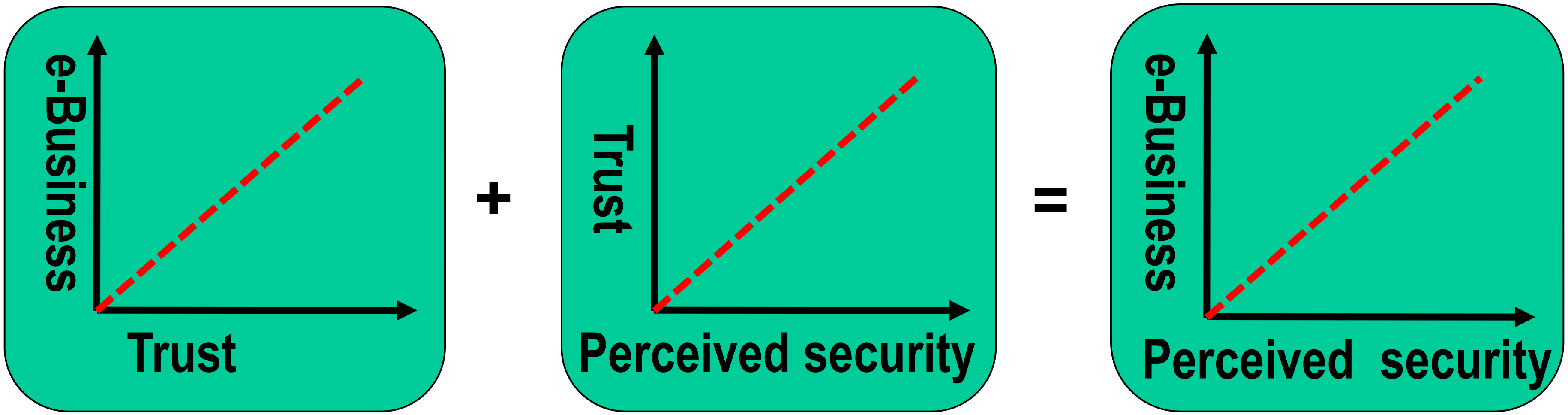


Real security is bad for e-business



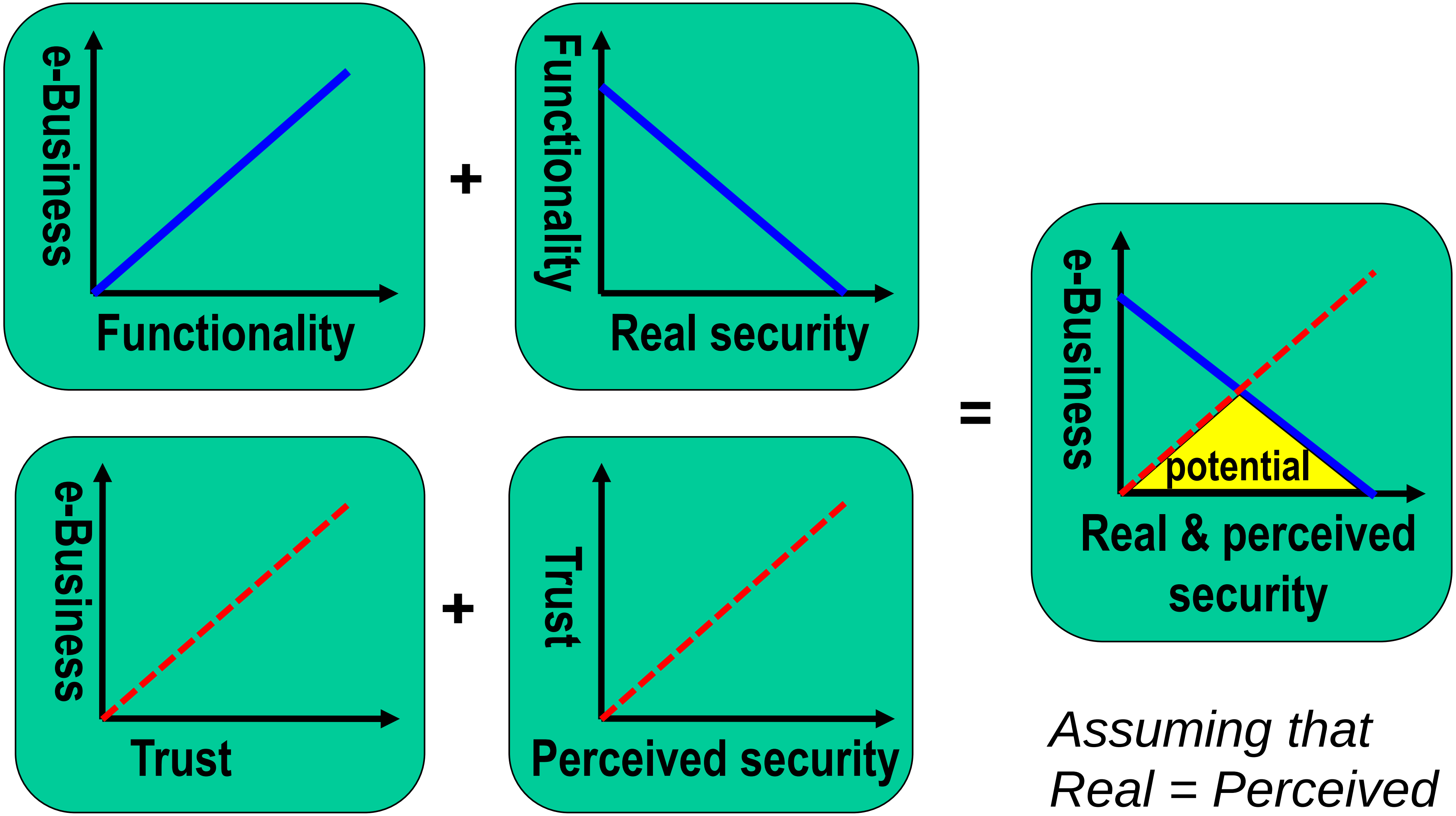
- e-business revolution not possible with real security
- Thank God the Internet isn’t secure

Perceived security is good for e-business



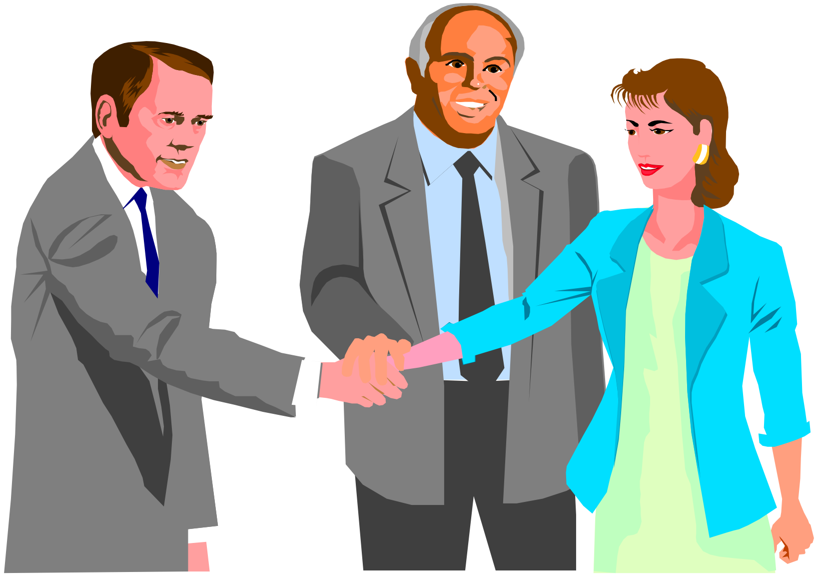
- e-business growth needs perceived security

e-Business growth potential



Assuming that Real = Perceived

Trust classes and semantics



The trust scope: What we trust

Trust scope classes:

Service provision trust

– Relying party's trust in services and service providers.

Access trust

– Service provider's trust in users

Identity trust

– Belief that an entity's identity is as claimed

Delegation trust

– Trust in a agent to make trust decisions on behalf of the relying party

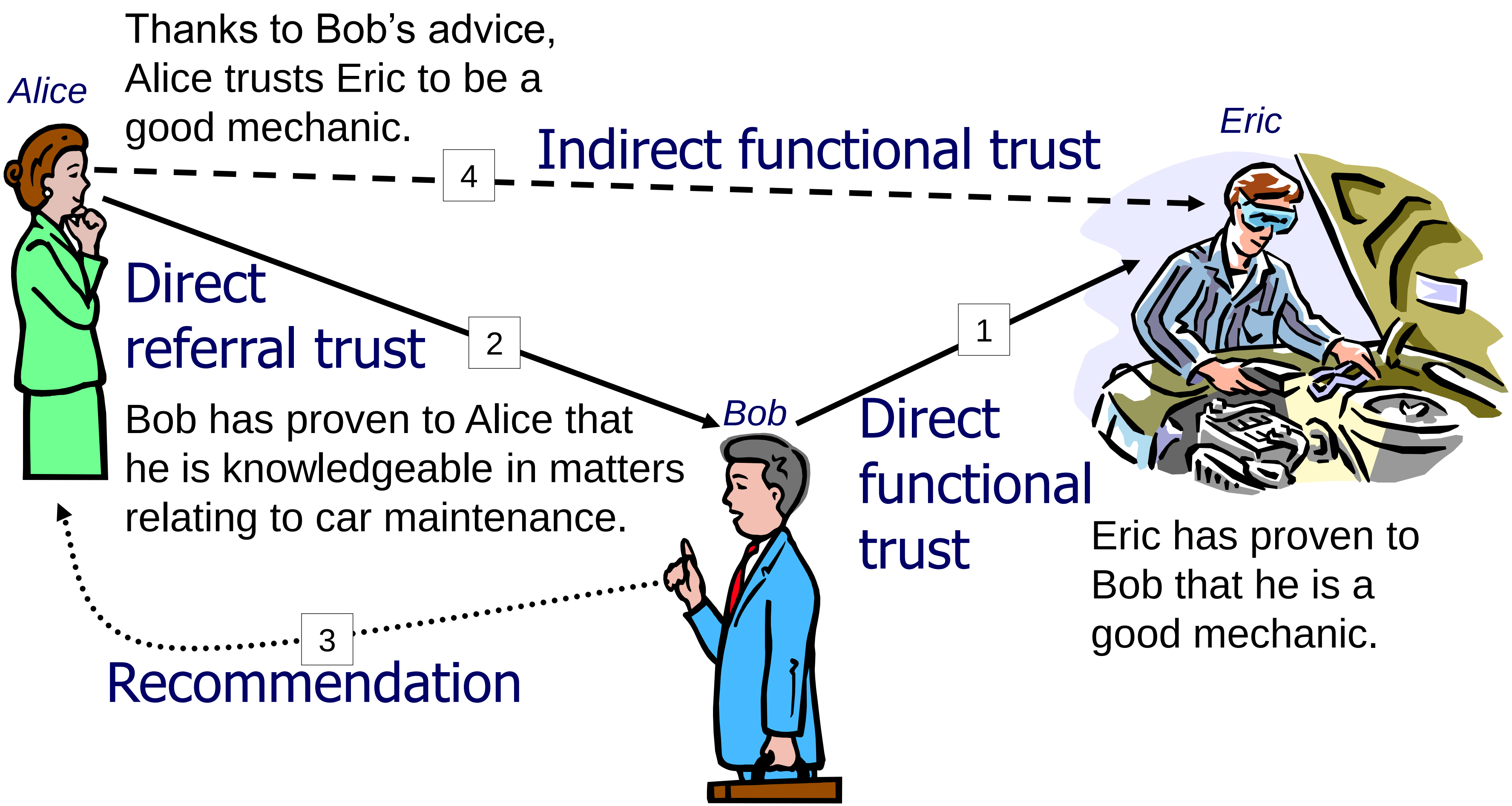
Context trust

– Belief that the necessary systems and institutions are in place in order to support a transaction that involves risk

Aspects of trust

- **Trust scope**
  - Function that the relying party depends on and trusts
- **Functional trust:**
  - The trusted party performs the function
- **Referral trust:**
  - The trusted party recommends a party (who recommends a party) that can perform the function
- **Direct trust:**
  - From direct experience
- **Indirect trust:**
  - From recommendations

Trust transitivity

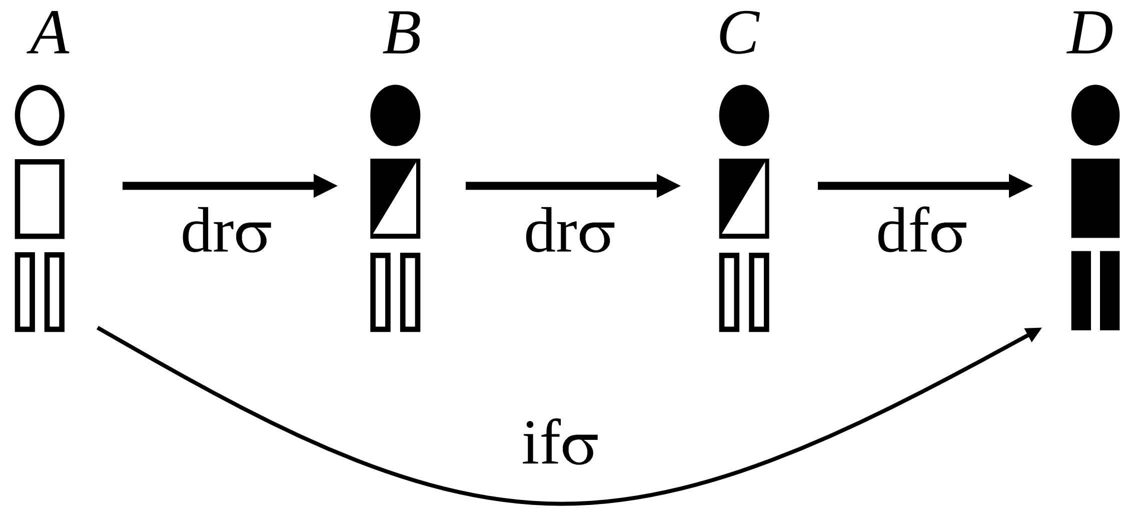


Additional aspects of trust

- Trust measure: μ
  - Binary (e.g. “Trusted”, “Not trusted”)
  - Discrete (strong-, weak-, trust or distrust)
  - Continuous (percentage, probability, belief)
- Time: τ
  - Time stamp when trust was assessed and expressed. Very important as trust generally weakens with temporal distance.

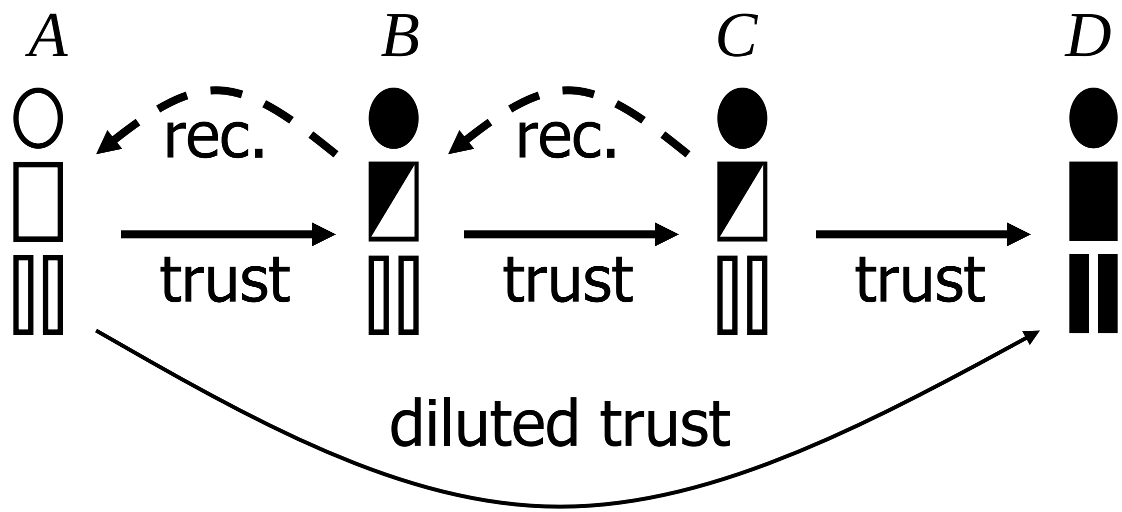
Valid transitive chains

- Every leg in the chain contains the same trust scope [σ]. (It doesn't make any sense otherwise!)
- The last trust link is **direct functional** trust [dfσ].
- All other trust links are **direct referral** trust [drσ].



Trust transitivity

Trust is diluted in a transitive chain.

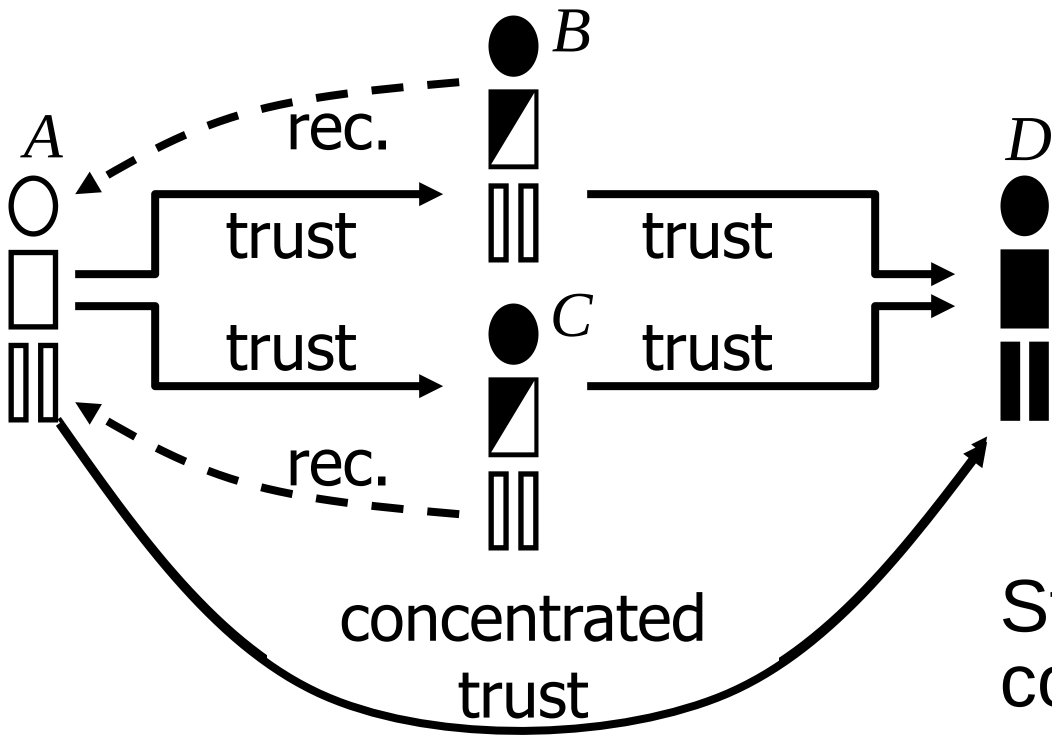


Can be computed with the transitivity operator

Graph notation: $[A, D] = [A, B] : [B, C] : [C, D]$

Explicit notation: $[A, D, \text{if}\sigma] = [A, B, \text{dr}\sigma] : [B, C, \text{dr}\sigma] : [C, D, \text{df}\sigma]$

Trust fusion

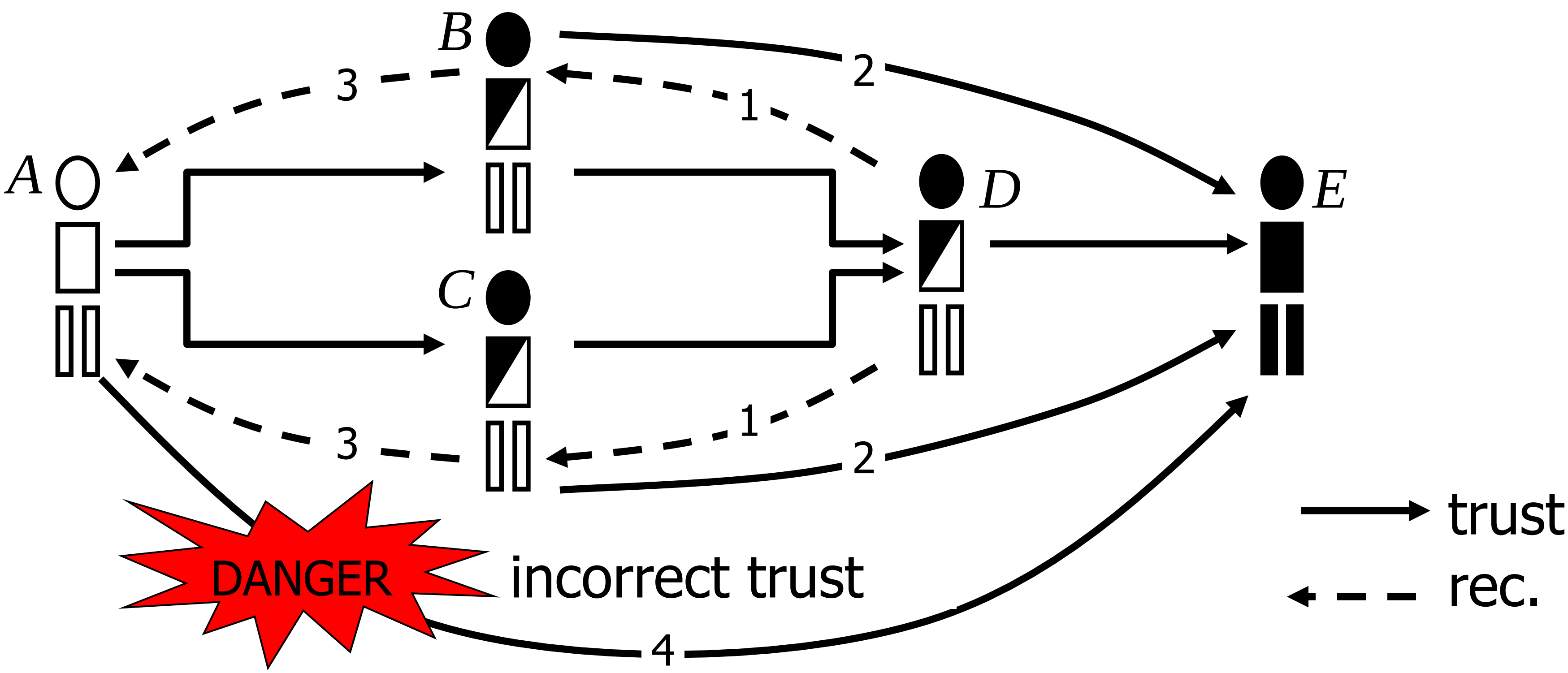


Strengthens trust confidence

Computed with the fusion operator of subjective logic

Graph notation: $[A, D] = ([A, B] : [B, D]) \quad ([A, C] : [C, D])$

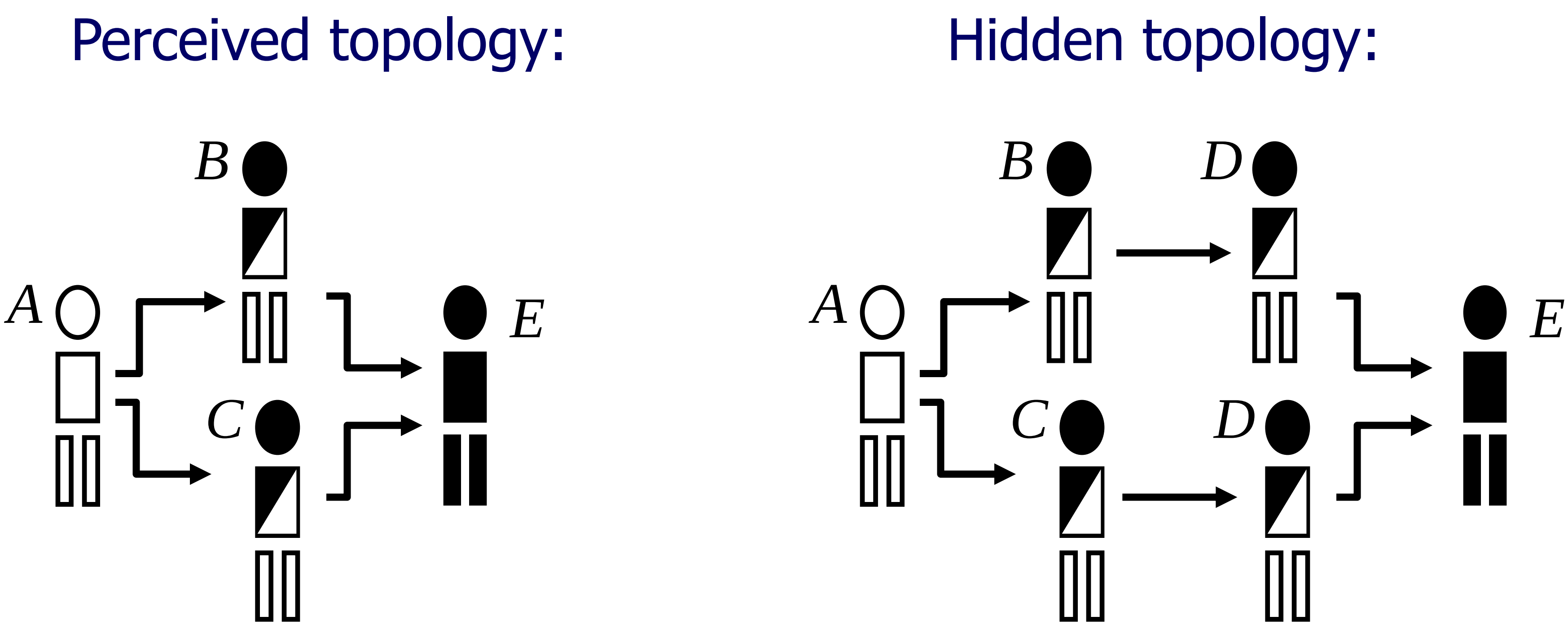
Indirect referral trust



Perceived $([A, B] : [B, E])$ $([A, C] : [C, E])$

Reality: $([A, B] : [B, D] : [D, E])$ $([A, C] : [C, D] : [D, E])$

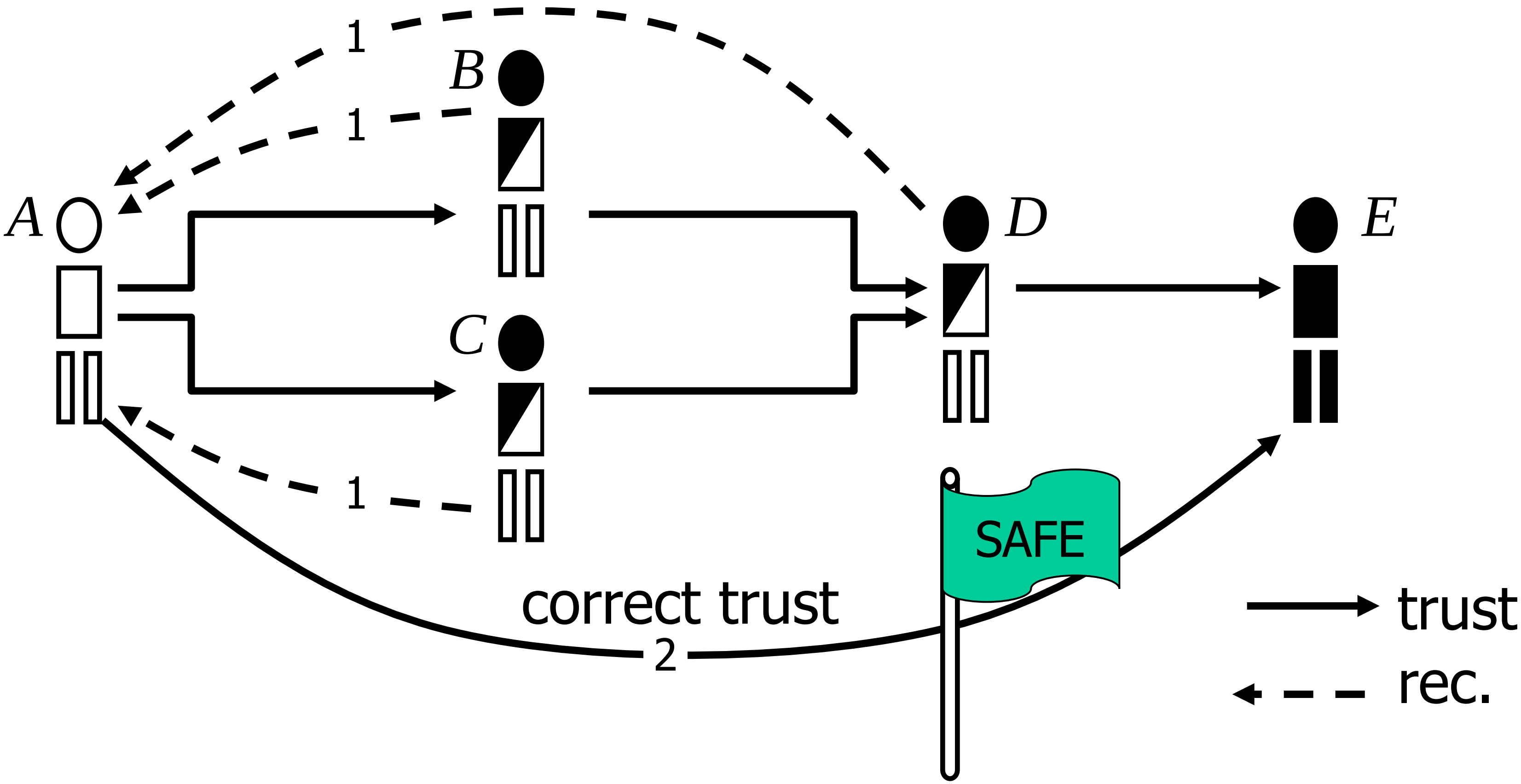
Hidden and perceived topologies



$$([A, B] : [B, E]) \lozenge ([A, C] : [C, E])$$
$$\neq ([A, B] : [B, D] : \mathbf{[D, E]}) \lozenge ([A, C] : [C, D] : \mathbf{[D, E]})$$

(D, E) is taken into account twice

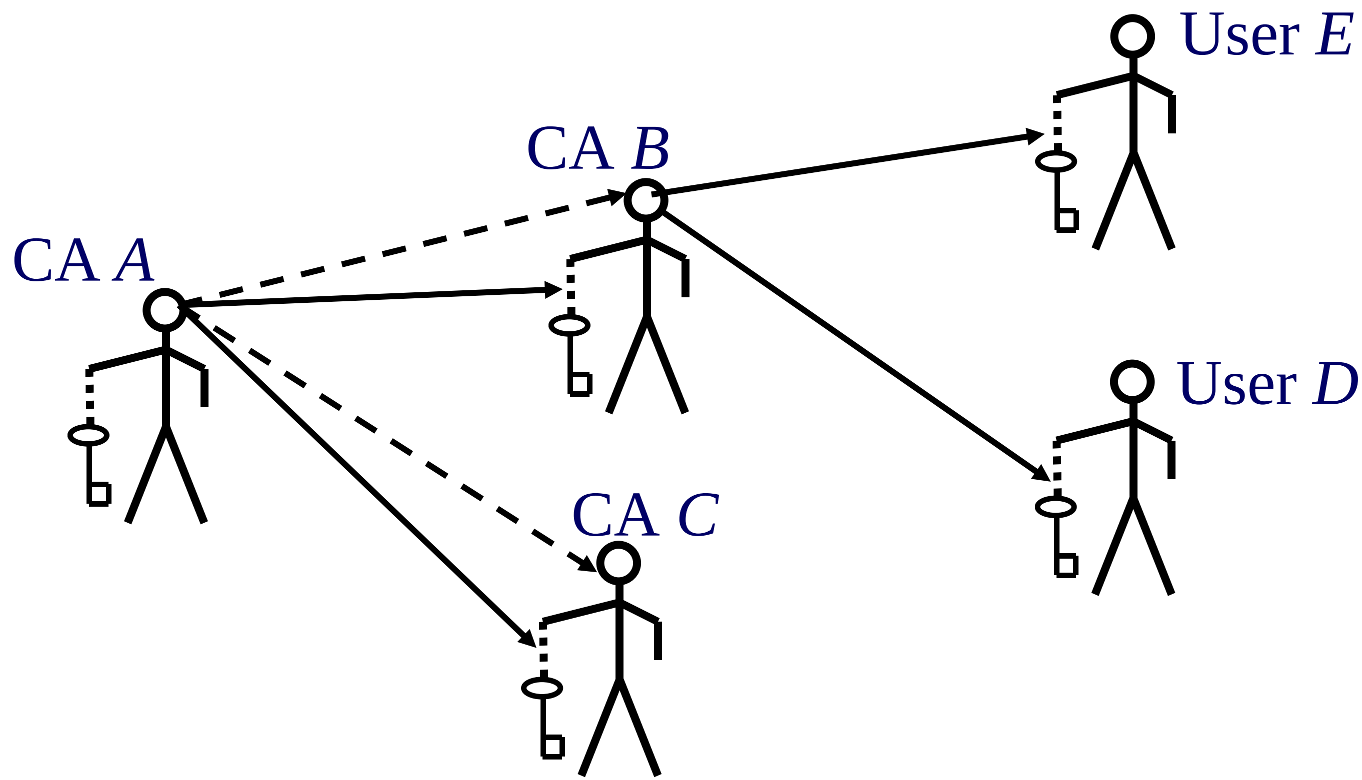
Correct indirect referral trust



Perceived and_real topologies are equal:

(([A, B] : [B, D])   ([A, C] : [C, D])) : [D, E]

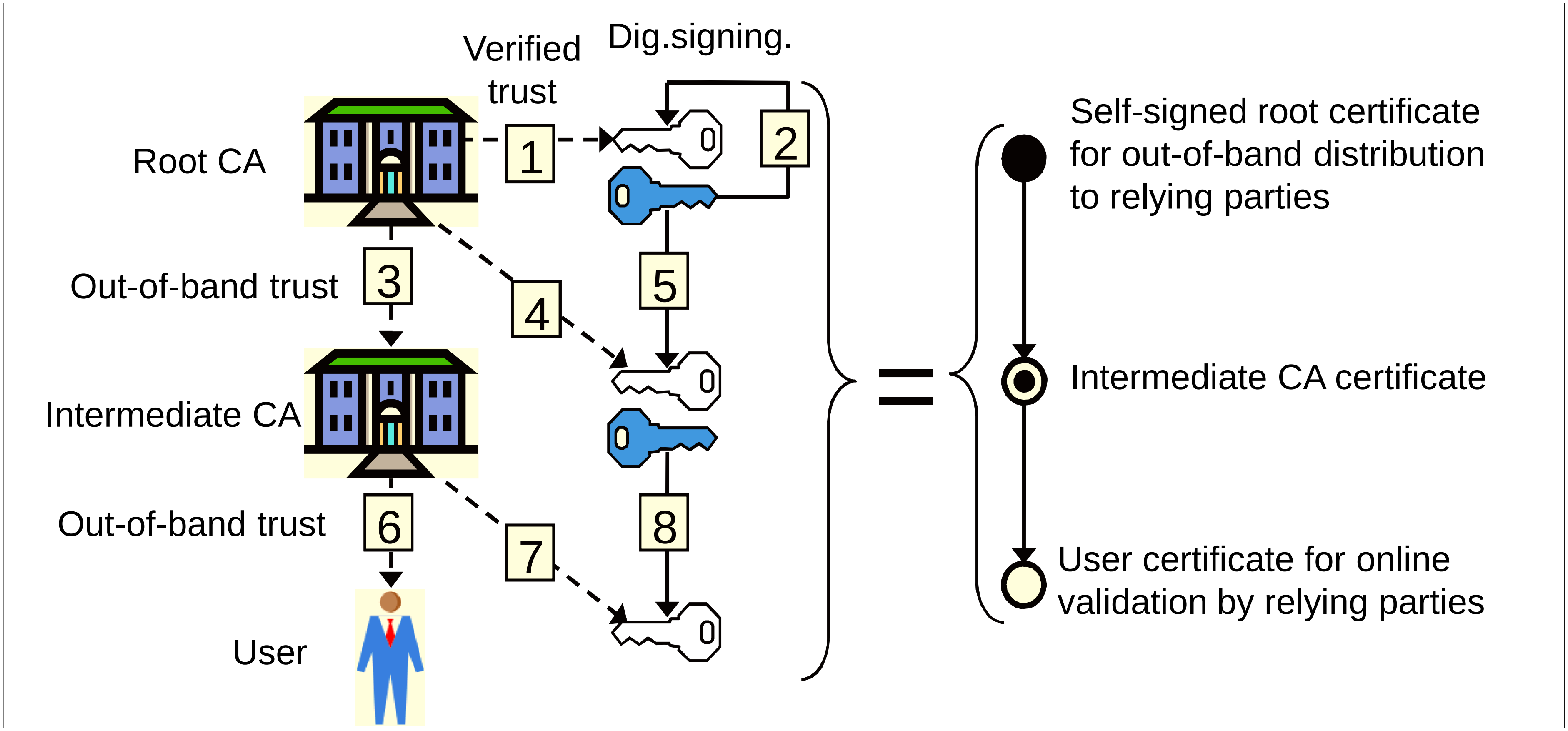
PKI and trust transitivity



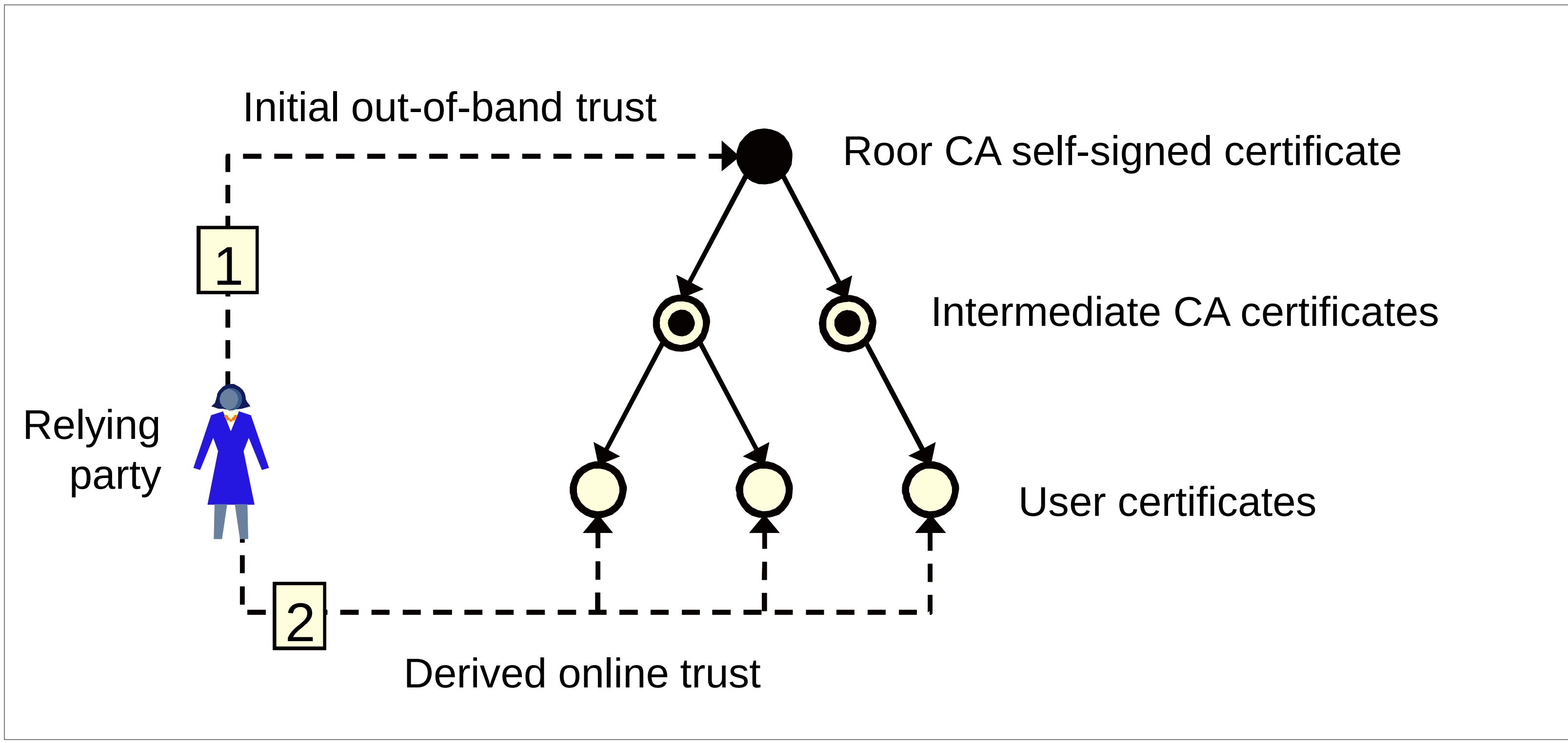
Trust in public keys (explicit through certificate chaining)

Trust in CA's (implicitly expressed through policies)

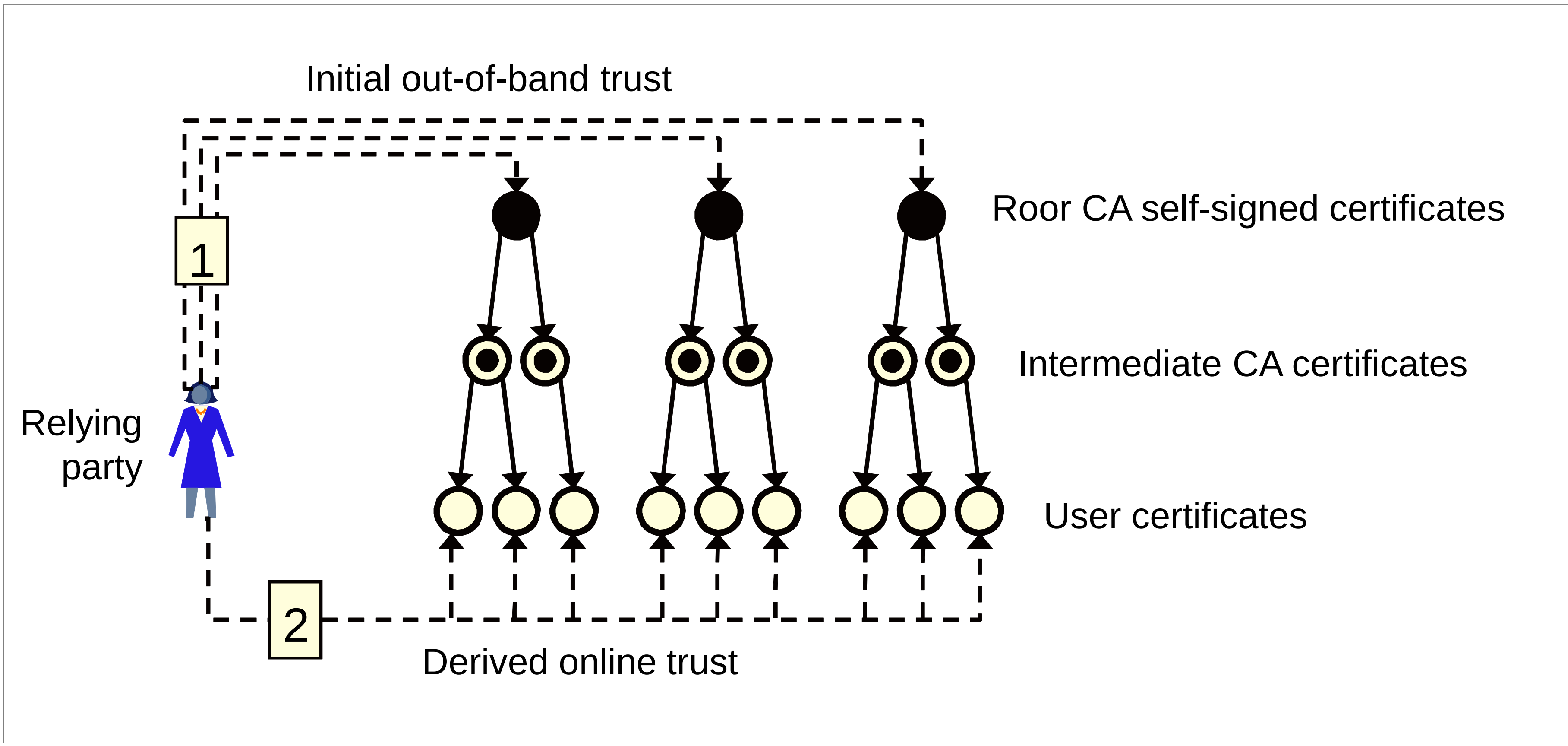
PKI identity trust



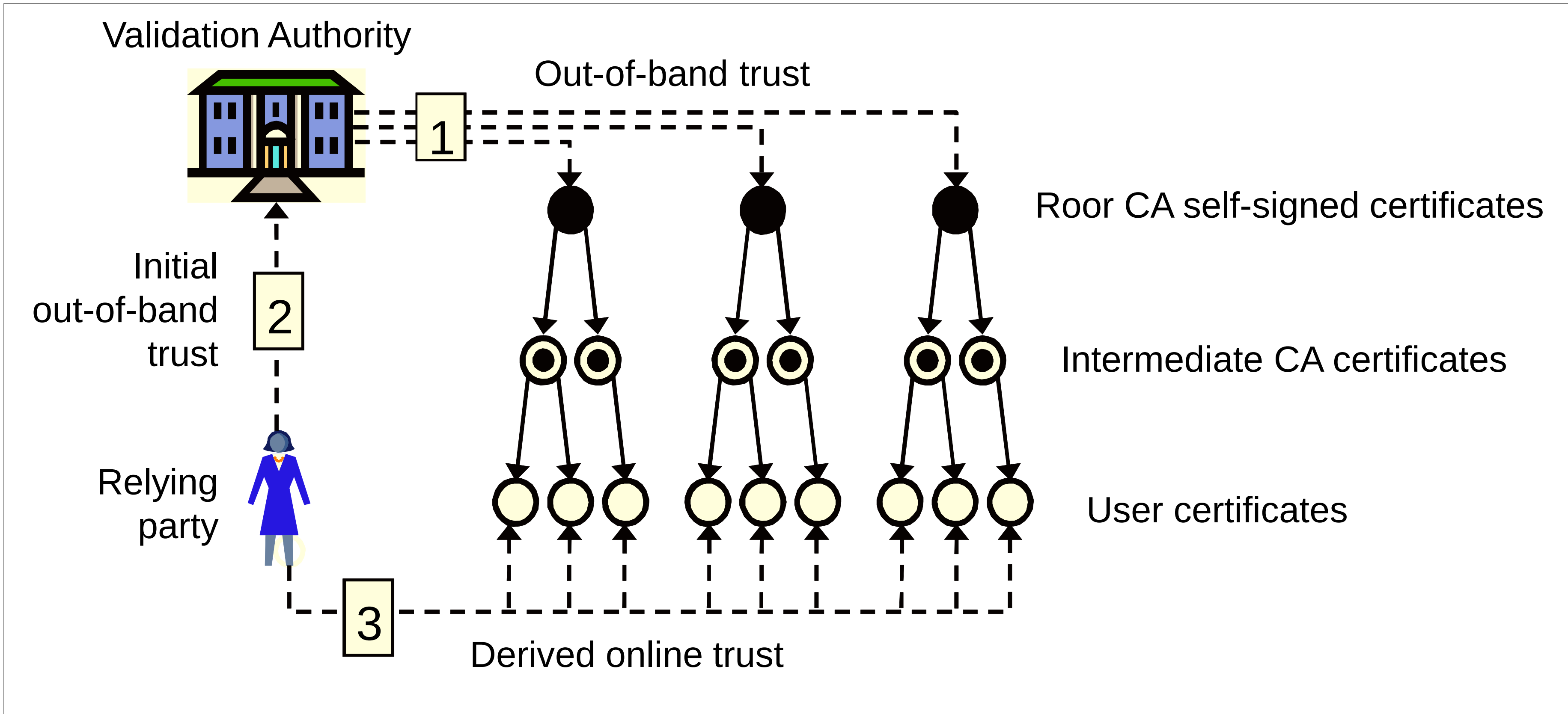
Simple certificate validation



Multi PKI environment



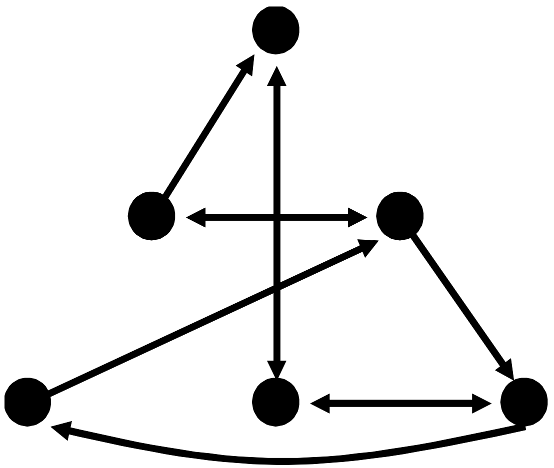
PKI with Validation Authority



PKI with unstructured web of trust

- Uni- and/or bidirectional between arbitrary agents.
- No difference between CA and user.
- Not generally possible to authenticate all users.

- Example: PGP
  - Pretty Good Privacy



PGP web of trust

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PGP trust model

- ***Owner Trust:*** trust in the owner of a public key
- ***Signature Trust:*** trust in received certificates
- ***Key Validity:*** trust in a public key

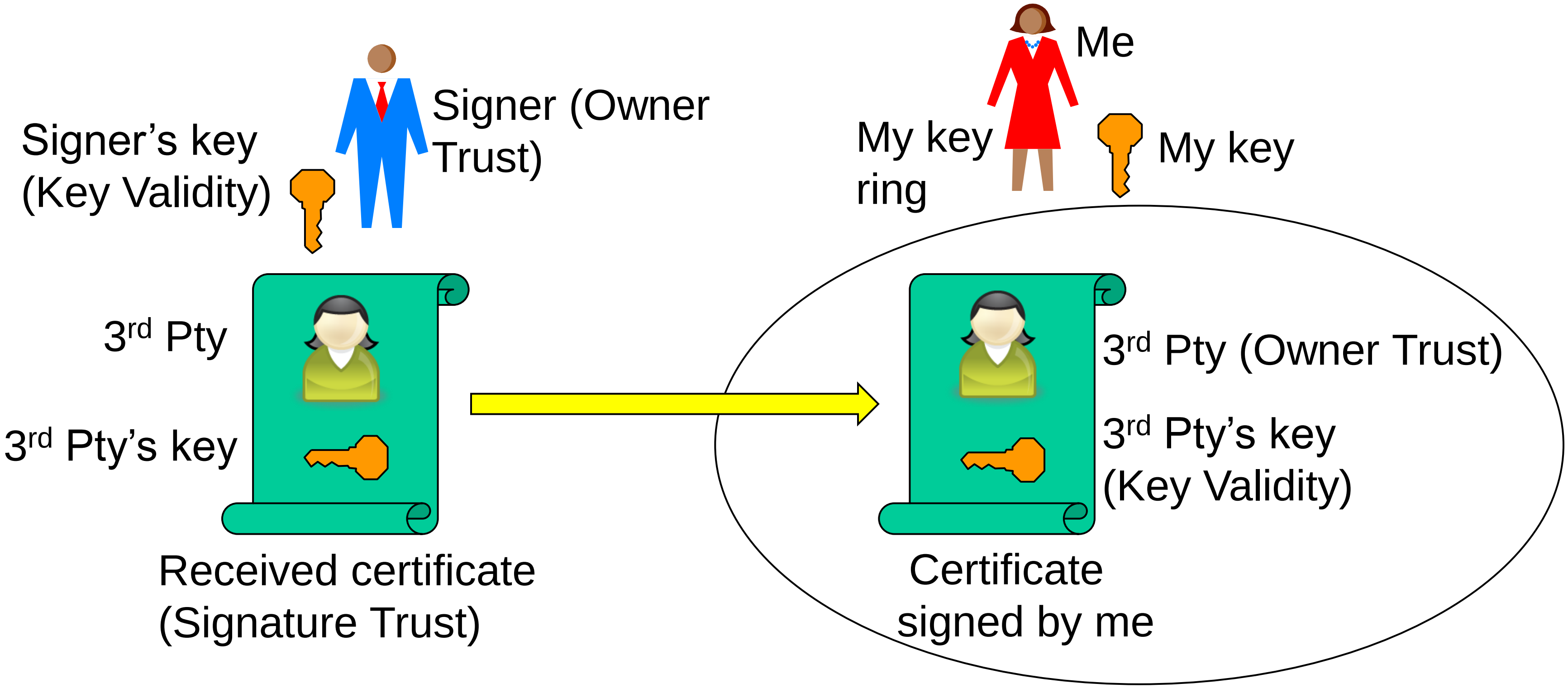
Owner Trust:
Signature Trust:

- *always trusted*
- *usually trusted*
- *not trusted*
- *unknown trust*

Key Validity:

- *complete*
- *marginal*
- *undefined*

PGP trust derivation overview



PGP trust derivation rules

1. Key Validity of received certificate signature key must be *complete*.
2. Signature trust := Owner Trust of signer
3. Owner trust of new key is manually set by Me
4. Key validity of new key is computed with Signature Trust values from one or several received certificates
5. By default PGP requires one *always trusted* or two *usually trusted* signatures in order to assign *complete* Key Validity
   - An insufficient number of *always trusted* or *usually trusted* signatures gives *marginal* Key Validity,
   - With no *usually trusted* signatures, Key Validity is se to *undefined*

Principles for building trust and reputation systems

Online v. brick and mortar world

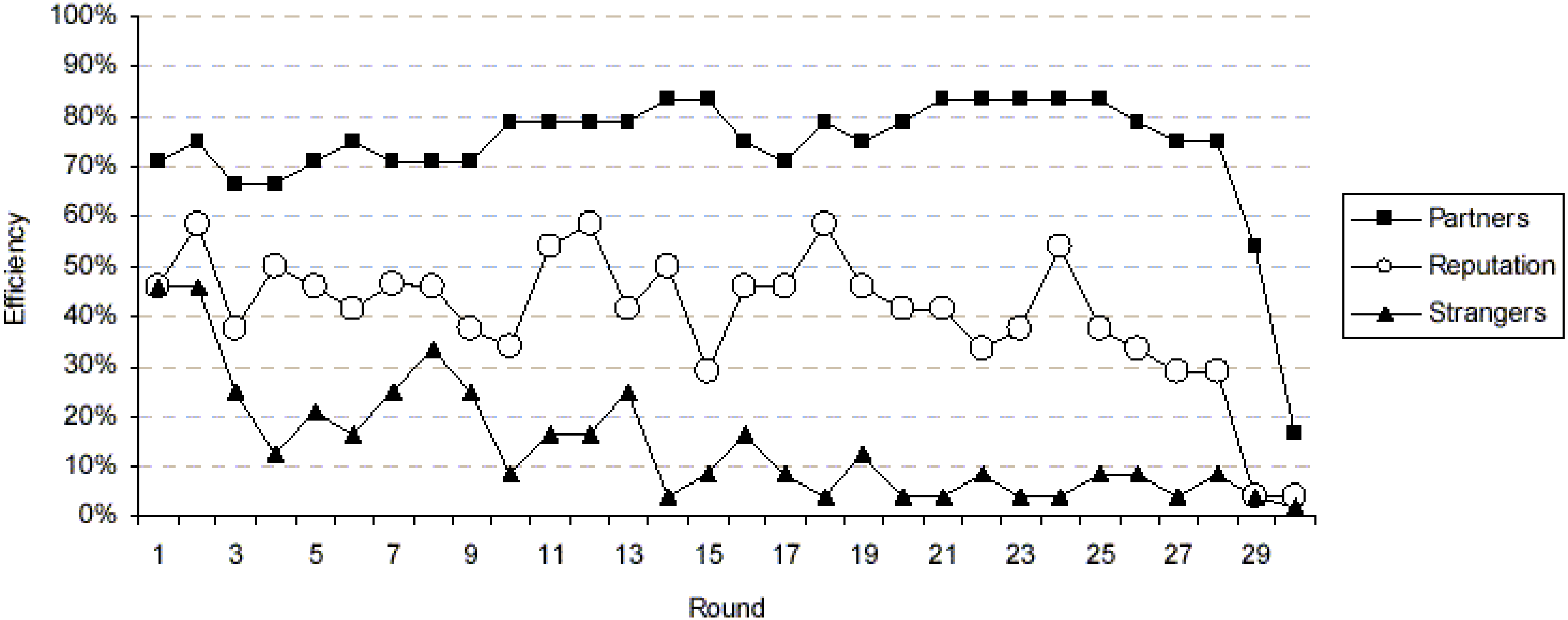
	Availability and richness of trust evidence	Efficiency of communication and processing
Brick & mortar	Good	Poor
Online	Poor	Good

- Communication of trust information often restricted to local community in the real world
- The online world currently provides very little reliable trust evidence

Basis for trust and rep. systems

- Focus on the trust evidence and on the methods for collecting this information
  - Find substitutes for traditional information used in physical world
  - Create new types of evidence
- Exploit the efficiency of IT and the Internet for
  - Collection of information
  - Processing
  - Dissemination

Market Efficiency Experiment

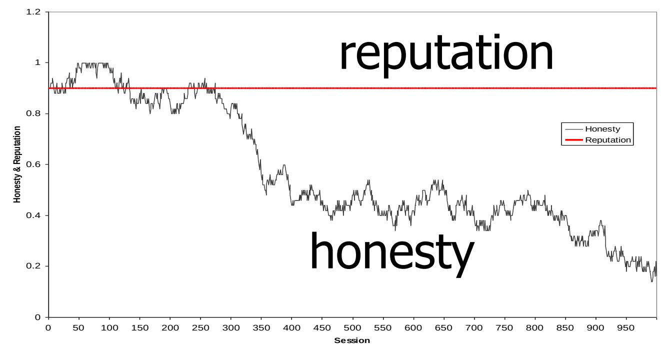


Source: Bolton,Katok,Ockenfels,2002

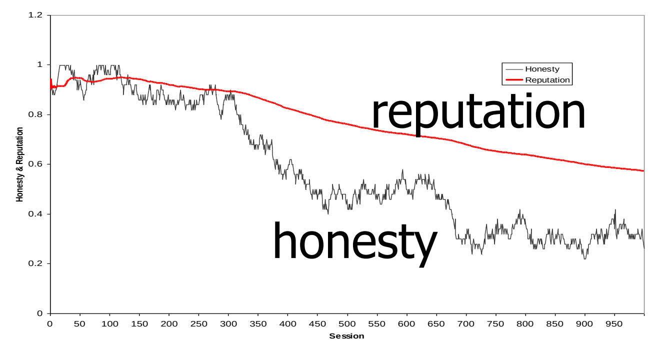
Simulation of the effect of reputation systems on e-markets

- Selling and buying software agents.
- Programmed to maximize profit by being dishonest.
- Reputation system enforces honesty

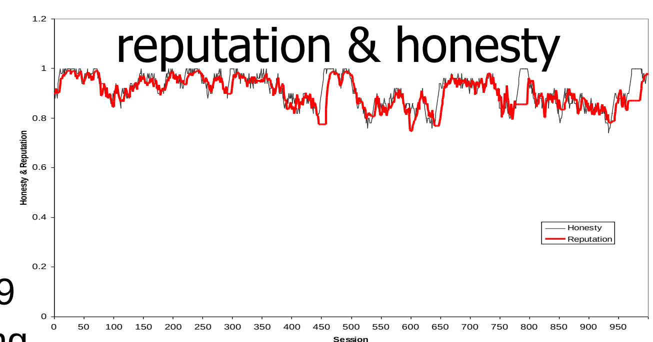
No ratings



Permanent ratings



Ageing ratings



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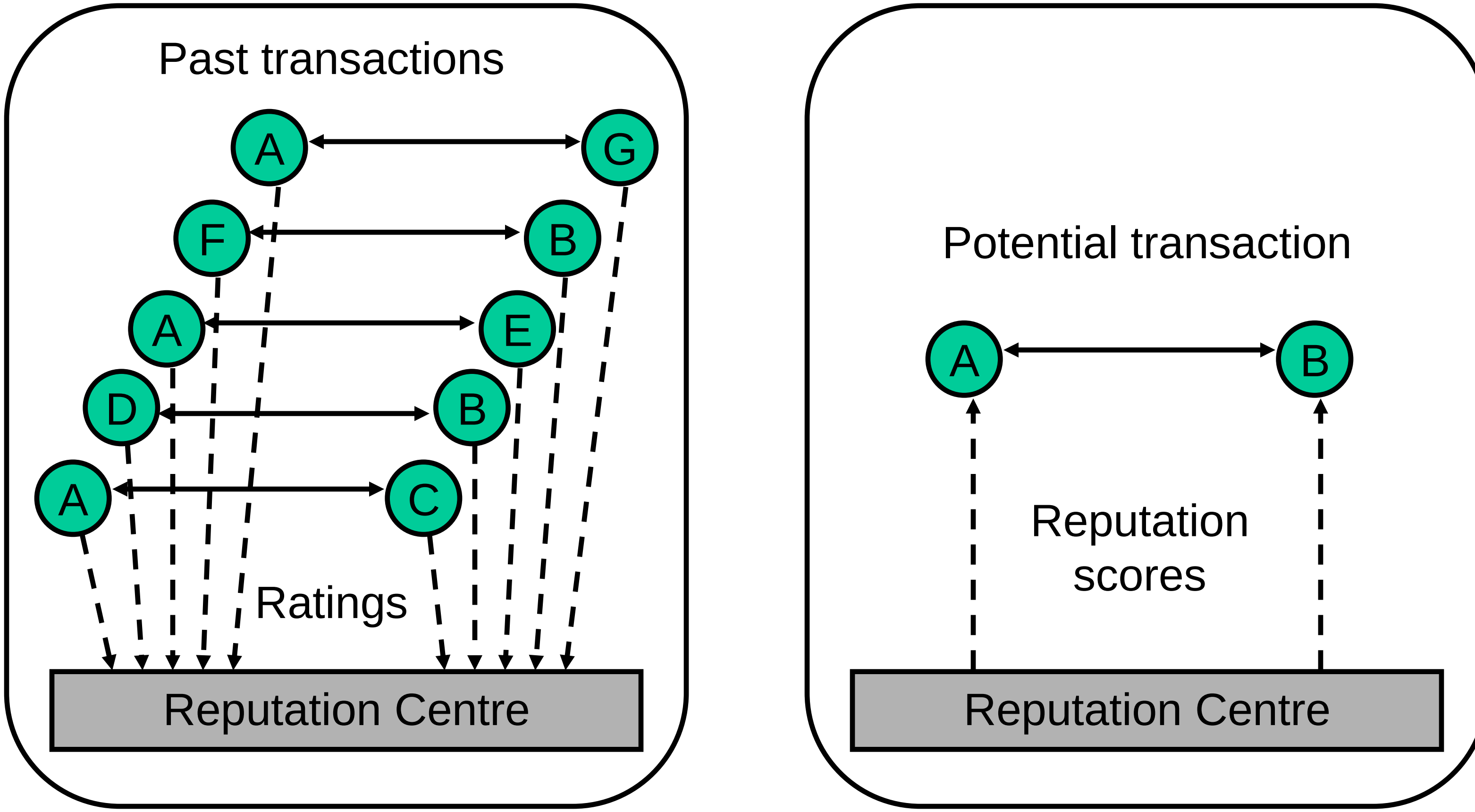
Trust/Reputation System Categories

	Private Scorers	Public Scores
Transitivity	Trust systems, e.g. Rummble.com	Public trust systems, e.g. PageRank
No transitivity	Private reputation systems, e.g. customer feedback analysis	Reputation systems, e.g. eBay.com

Applications

- e-Auctions
- Social websites
- Online markets: B2C, B2B, C2C
- P2P networks
- Software agent communities
- Contract negotiations
- Web service search and selection
- Spam filtering

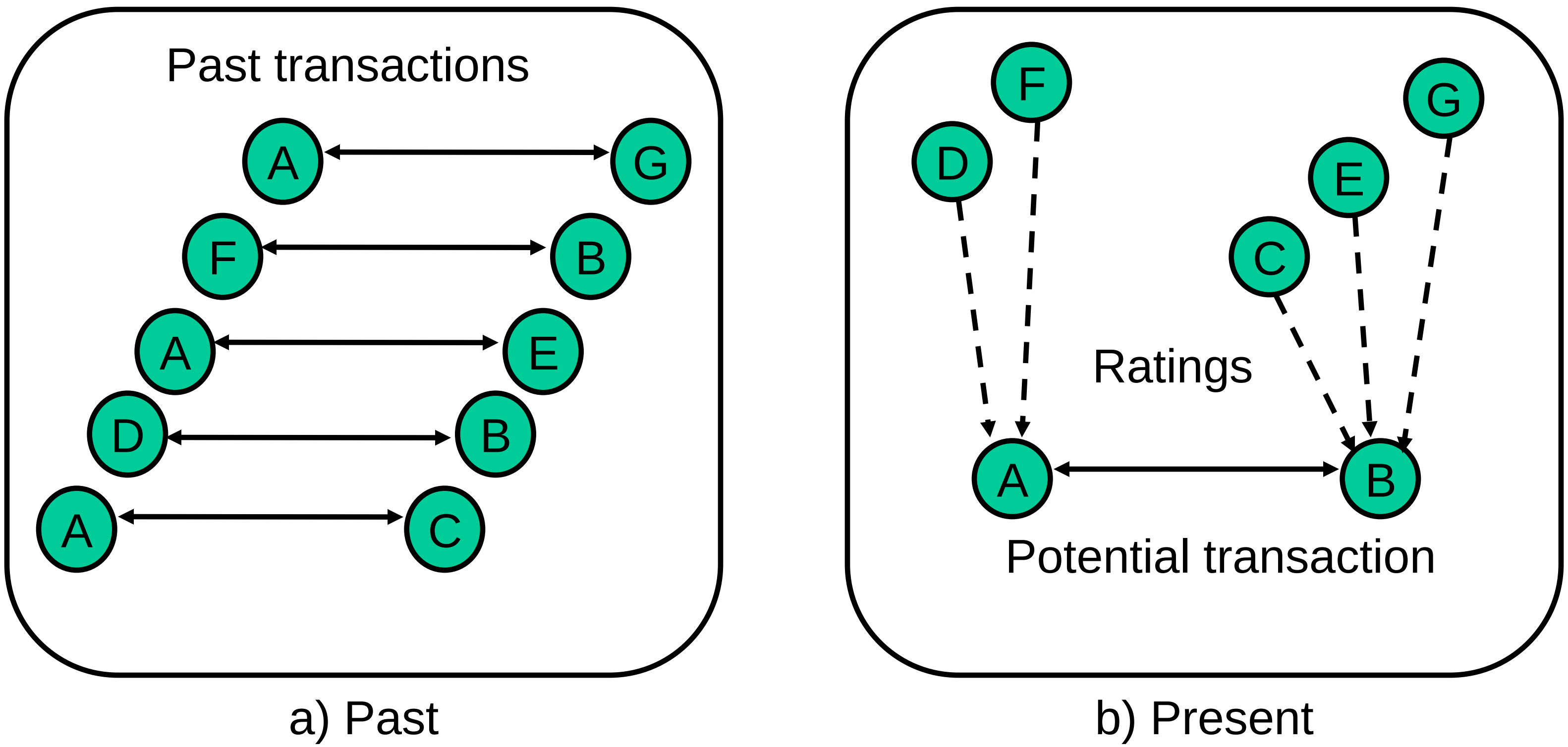
Centralised reputation system



a) Past

b) Present

Distributed reputation system

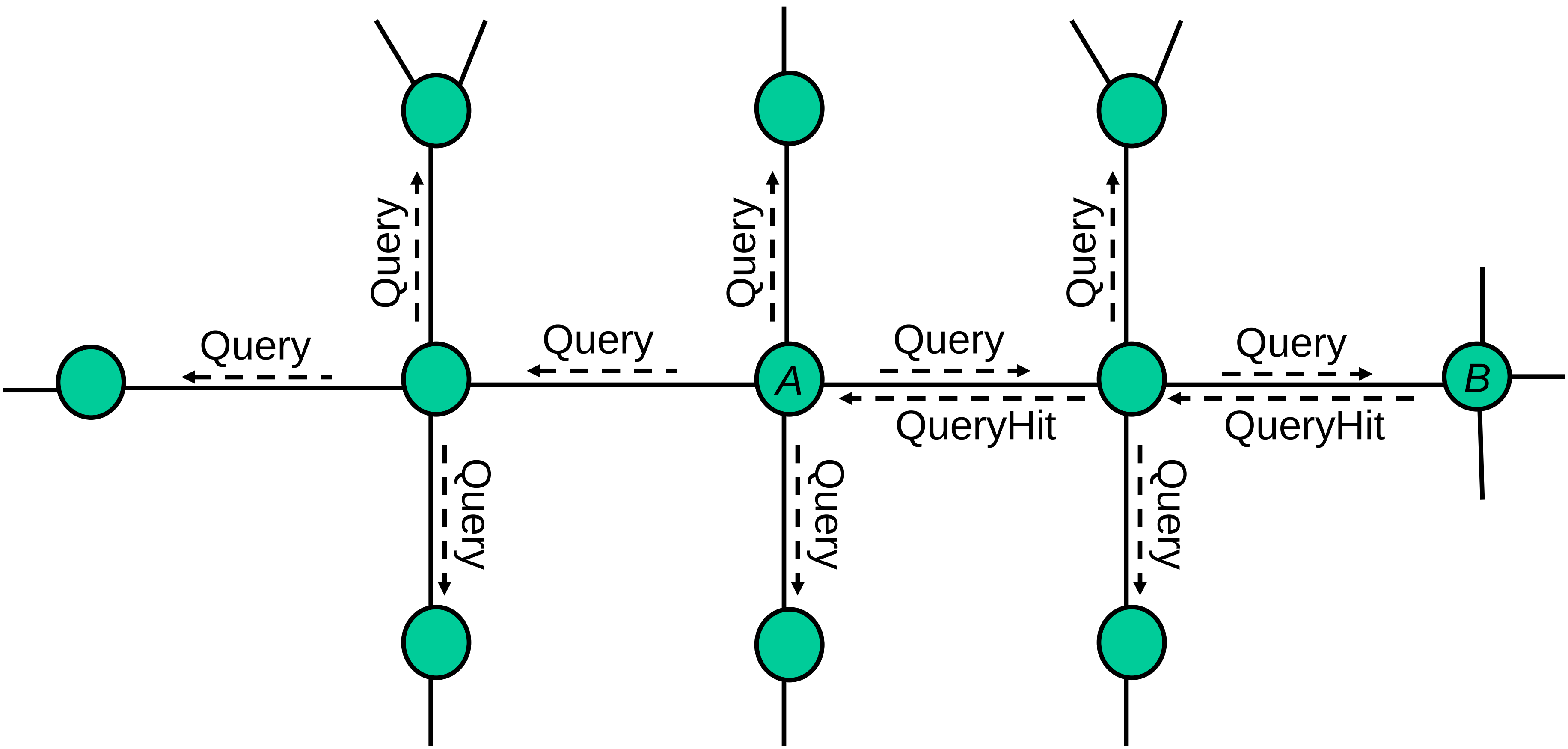


P2P networks

- P2P Networks: servent = server + client
- Search phase: discover resources
  - Centralised: e.g. Napster, with central directory
  - Pure distributed: Gnutella, Freenet
  - Semi-distributed: FastTrack, KaZaA, grokster, with distributed directory servers
- Download phase: get the resources
- Problems
  - Spreading malware
  - Free riding
  - Poisoning

Gnutella example

- Pure distributed search phase



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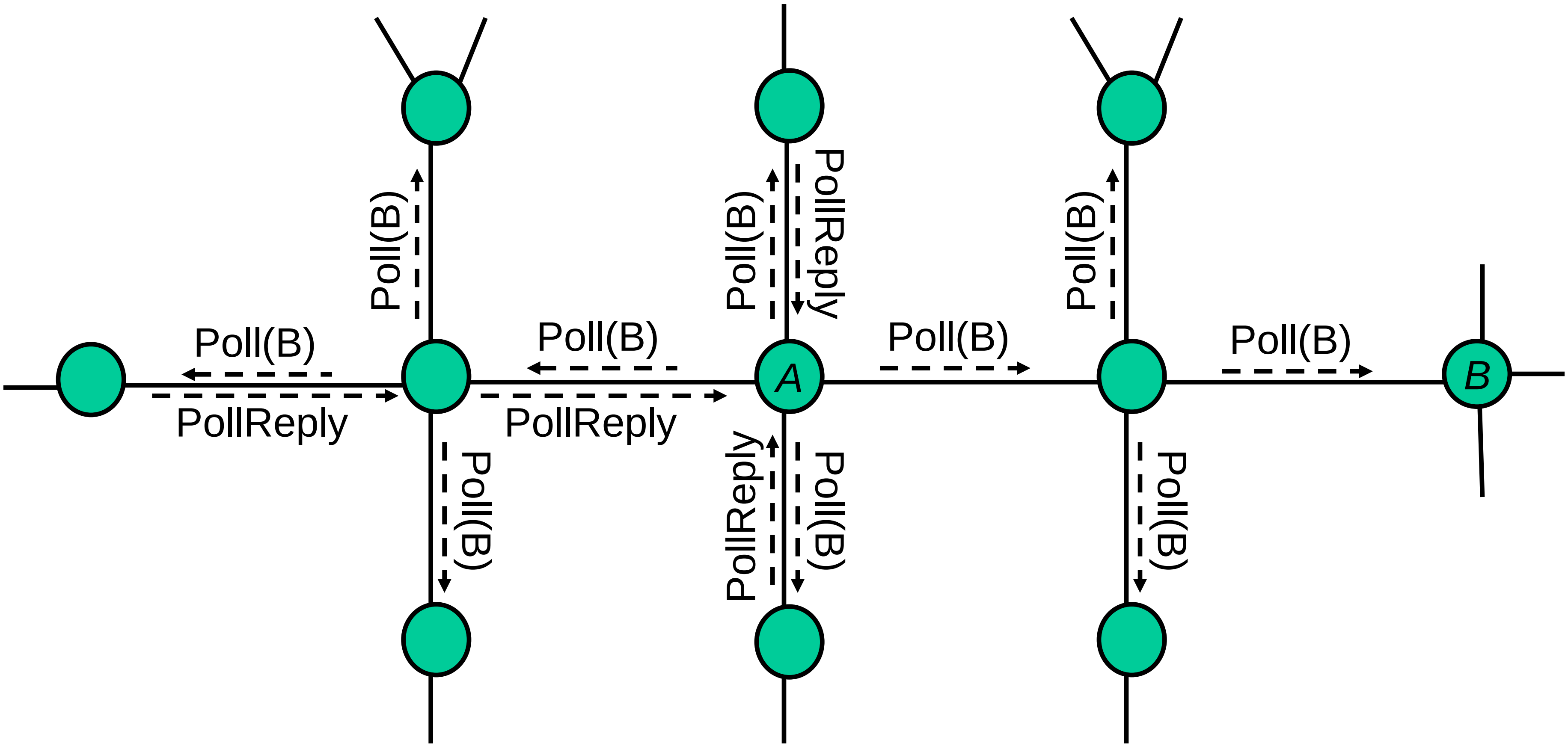
Reputation/trust system with Gnutella

- XRep proposed by Damiani *et al.*



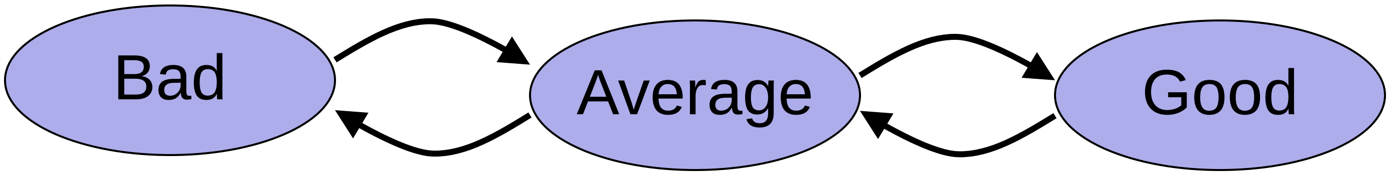
Trust and reputation computation engines

- Summation or average
- Hidden Markov
- Bayesian models
- Discrete models
- Belief models
- Fuzzy models
- Flow models

Summation and average

- Summation
  - Reputation score = Σ(positive) - Σ(negative)
  - E.g. eBay
- Average
  - Reputation score = Σ(ratings)/N(ratings)
  - E.g. Epinions
- Can be combined with sliding time windows
- Simple to understand
- Can give false impression of reputation

Hidden Markov Model



- True nature of future services unknown
- State of service/SP modelled as a Markov chain
- Statistically sound
- Requires parameters

Bayesian Reputation Systems

- Theoretically sound rating algorithm.
- Binomial and multinomial models.
- Rating possibilities:
  - any range,
  - combination,
  - discounting,
  - longevity,
  - weight ~ transaction value.

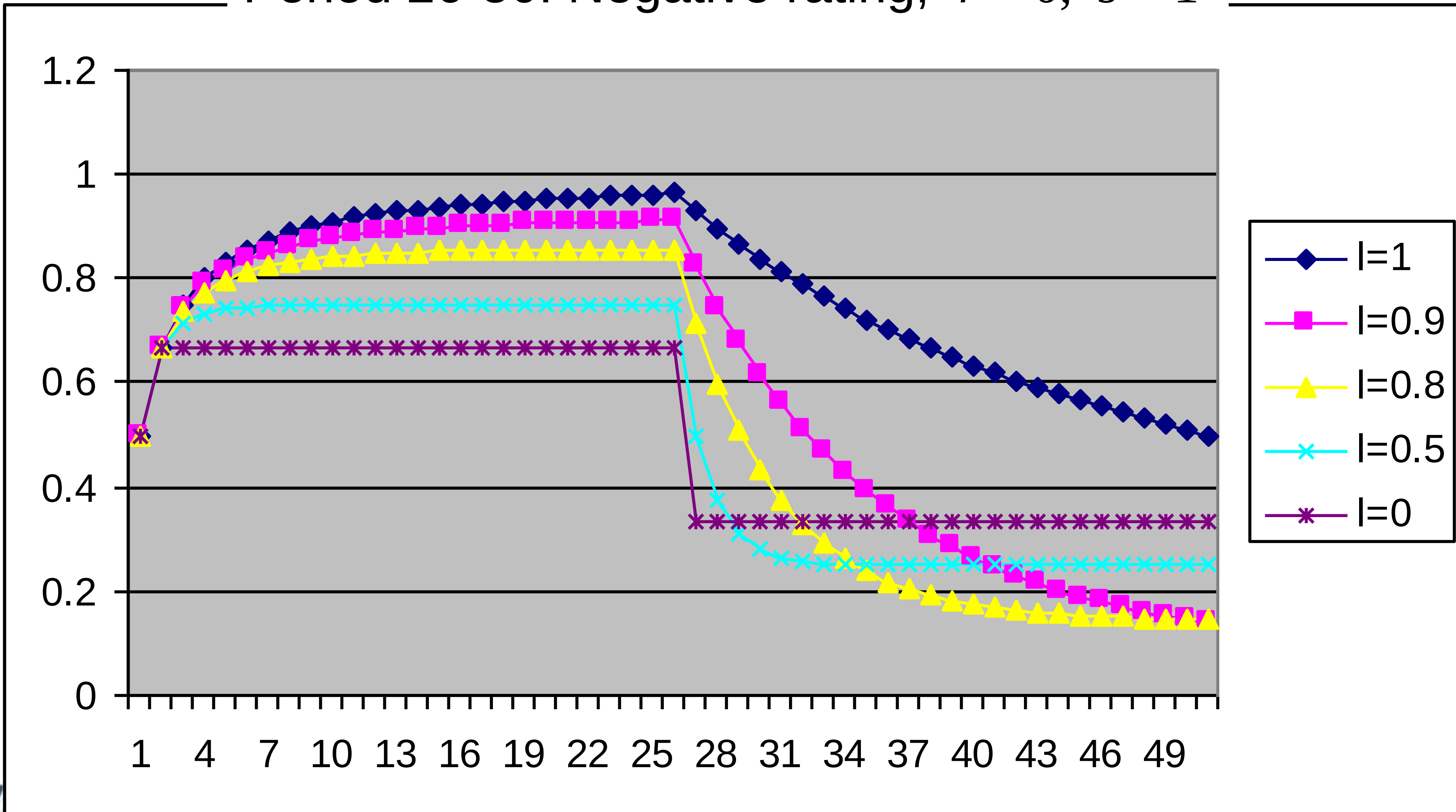
Computing binomial reputation over time with longevity factor

- R_i : accumulated positive evidence at time i
- S_i : accumulated negative evidence at time i
- r : positive evidence during 1 time period
- s : negative evidence during 1 time period
- λ : longevity factor in range [0,1]
- $R_{i+1} = \lambda \cdot R_i + r$: Recursive updating algorithm
- $S_{i+1} = \lambda \cdot S_i + s$: Recursive updating algorithm
- $\text{Score}_i = \dfrac{r_{\text{base}} + R_i}{r_{\text{base}} + s_{\text{base}} + R_i + S_i}$: Score at time period i
- Typically, $r_{\text{base}} = 1$, $s_{\text{base}} = 1$

Score evolution with different longevity

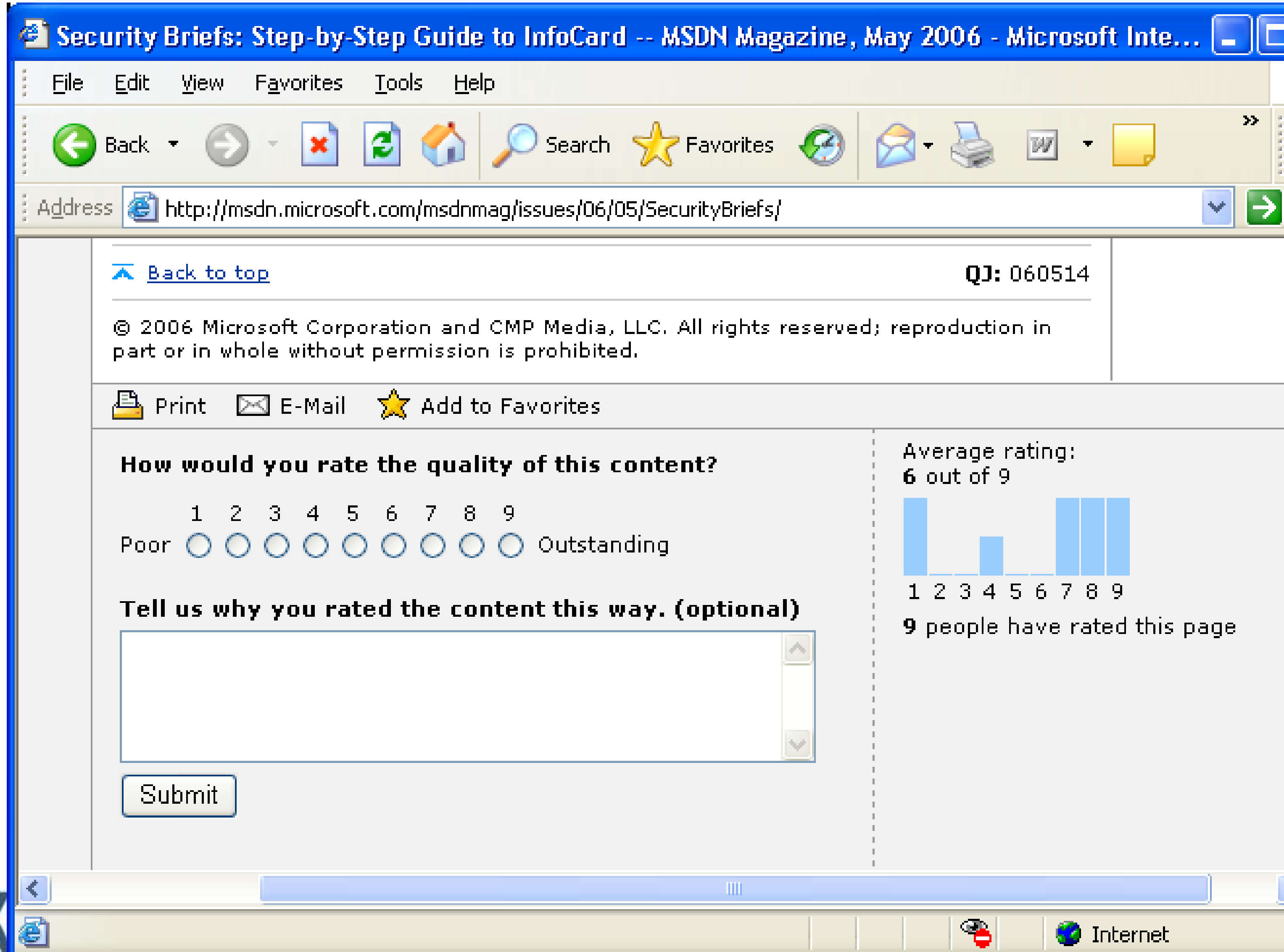
Period 1-25: Positive rating, $r = 1, \; s = 0$

Period 26-50: Negative rating, $r = 0, \; s = 1$



Multinomial reputation example

- Example from Microsoft
- Reflects polarised ratings



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Multinomial reputation score

- The multinomial reputation score can be defined equal to the Dirichlet-PDF probability expectation

$$\text{Score}(L_j \mid \vec{R}, \vec{a}) = \frac{R(L_j) + W \cdot a(L_j)}{W + \sum_{j=1}^{l} R(L_j)}$$

Rep. score

$\vec{r}$:	Multinomial evidence vector
$\vec{a}$:	Multinomial base rate vector
$W = 2$	Weight of non-informative prior
l :	Number of rating levels
L_j :	particular rating level

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Initial reputation score

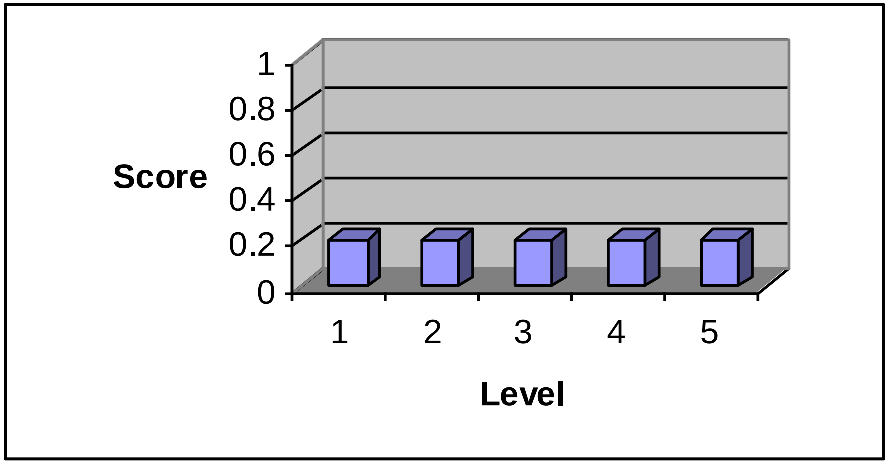
Example with $l = 5$ discrete rating levels:

1) mediocre, 2) bad, 3) average, 4) good, 5) excellent

Initial uniform reputation score before any ratings have been received.

Base rate $a(x_i)= 0.2$

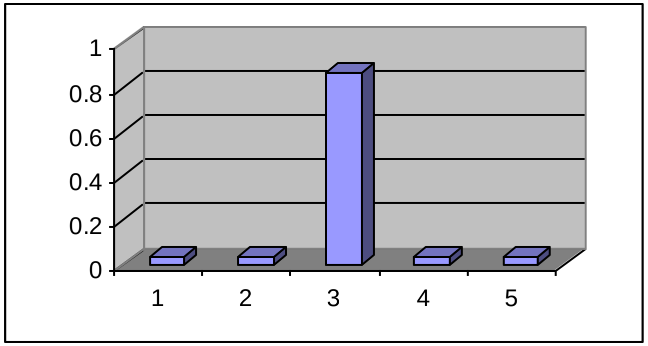
Can represent polarised ratings!



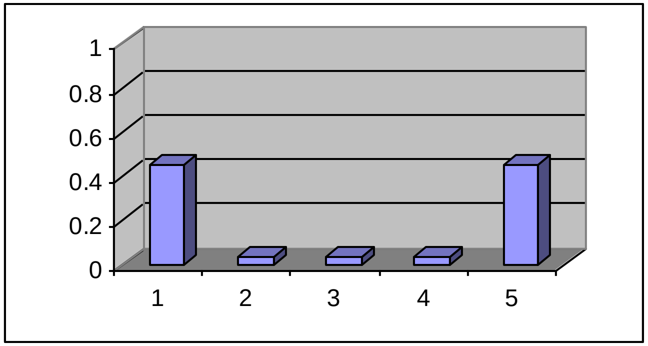
Reputation score of polarise ratings

As before, 5 discrete levels:

1) very bad, 2) bad, 3) average, 4) good, 5) very good



Non-polarised reputation score after 10 average ratings



Polarised reputation score after 5 very bad and 5 very good ratings

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Computing multinomial reputation with fixed base rate

- $\vec{R}_i$: accumulated evidence at time i
- $\vec{r}$: evidence collected during 1 time period.
- λ : longevity factor
- $\vec{R}_i = \lambda \cdot \vec{R}_{i-1} + \vec{r}$: Recursive updating algorithm
- $\mathrm{Score}_i(L_j \mid \vec{R}_i, \vec{a})$: Score at time period i

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Score evolution over time with fixed base rate

Five discrete rating levels:

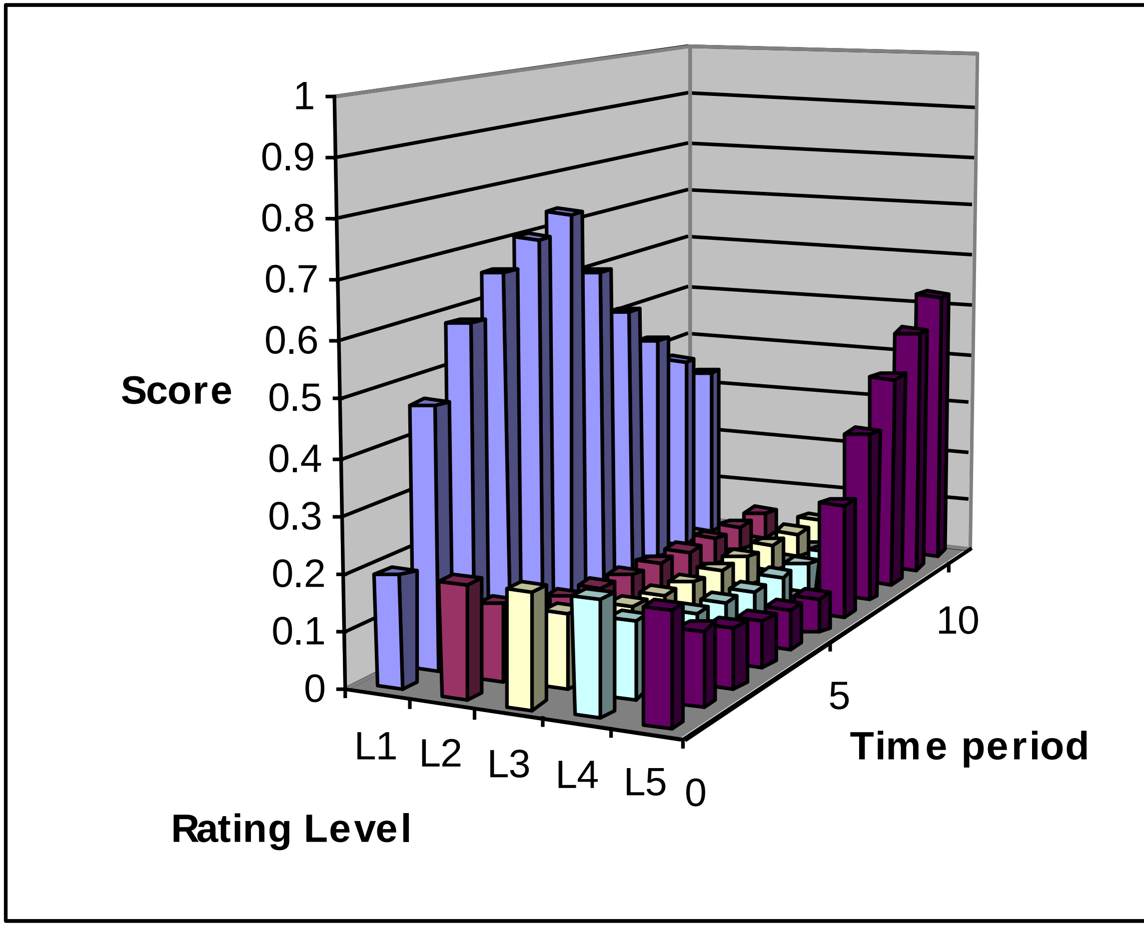
1. Mediocre
2. Bad,
3. Average,
4. Good,
5. Excellent

Longevity $\lambda = 0.9$

Base rate $a(x) = 0.2$

Periods 1-5: Mediocre

Periods 6-10: Excellent



Convergence values

- For an infinite series of positive ratings $r = 1, s = 0$
  - $R_\infty = 1/(1-\lambda)$
  - $S_\infty = 0$
  - Score converges to $Sc(Z) = \frac{2-\lambda}{3-2\lambda}$ (with $r_{\text{base}} = s_{\text{base}} = 1$)
- For an infinite series of negative ratings $r = 0, s = 1$
  - $R_\infty = 0$
  - $S_\infty = 1/(1-\lambda)$
  - Score converges to $Sc(Z) = \frac{1-\lambda}{3-2\lambda}$ (with $r_{\text{base}} = s_{\text{base}} = 1$)

Score evolution over time with fixed base rate

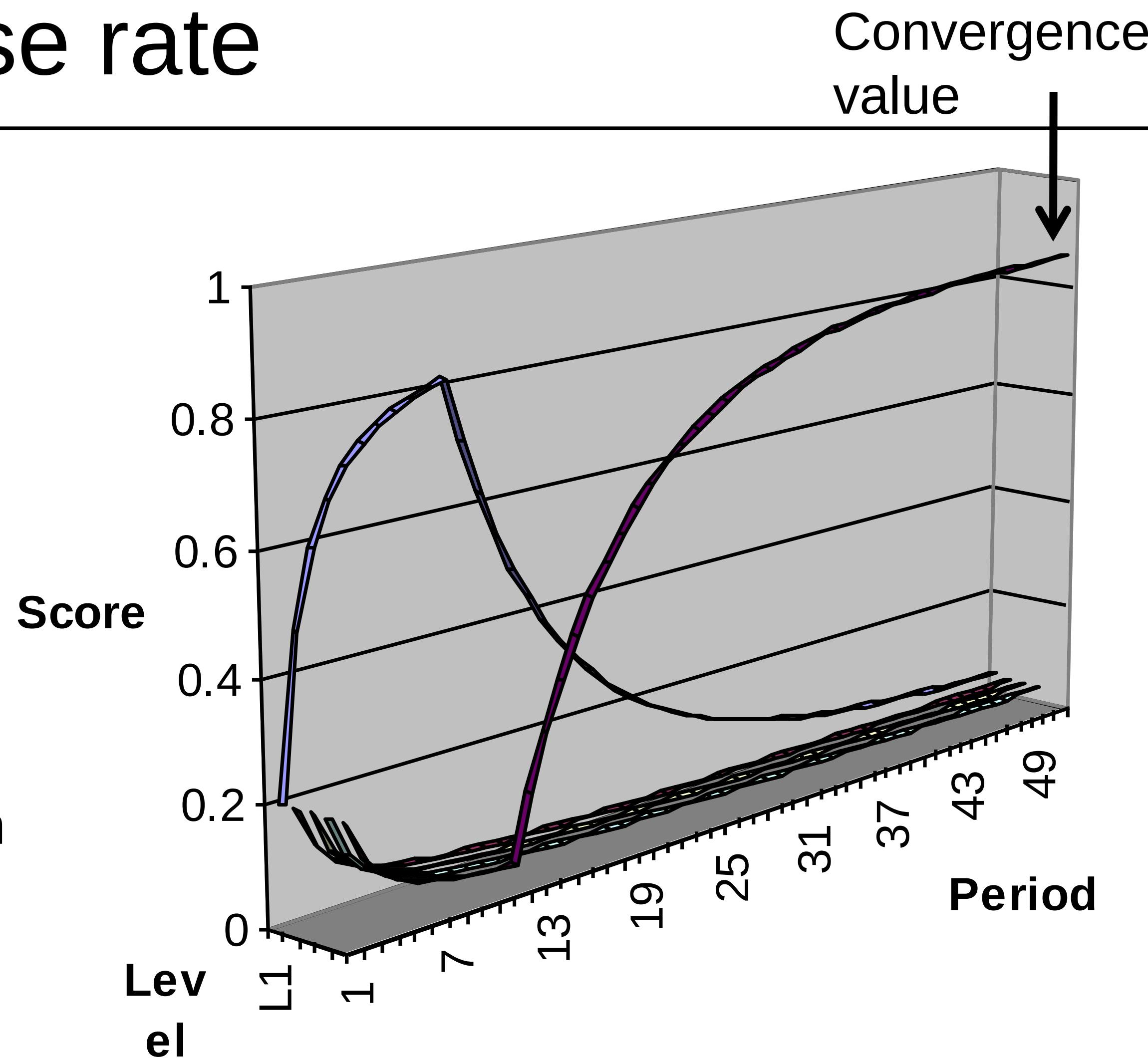
Longevity λ= 0.9

Base rate $a(x)$ = 0.2

Periods 1-10: Mediocre

Periods 11-50: Excellent

The max and min reputation score is determined by the longevity factor λ



Individual Base Rates

- High longevity factor: λ_{H} with value close to 1 (e.g. 0.999)
- Individual cumulative evidence: $\vec{Q}_i = \lambda_{\mathrm{H}} \cdot \vec{Q}_{i-1} + \vec{r}$
- Individual base rate: $a_A(L_j) = \dfrac{Q_A(L_j) + W \cdot a(L_j)}{W + \sum_{j=1}^{l} Q_A(L_j)}$
- Score with individual base rate: $\mathrm{S}_A(L_j \mid \vec{R}, \vec{a}_A) = \dfrac{R(L_j) + W \cdot a_A(L_j)}{W + \sum_{j=1}^{l} R(L_j)}$

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Score evolution over time with individual base rate

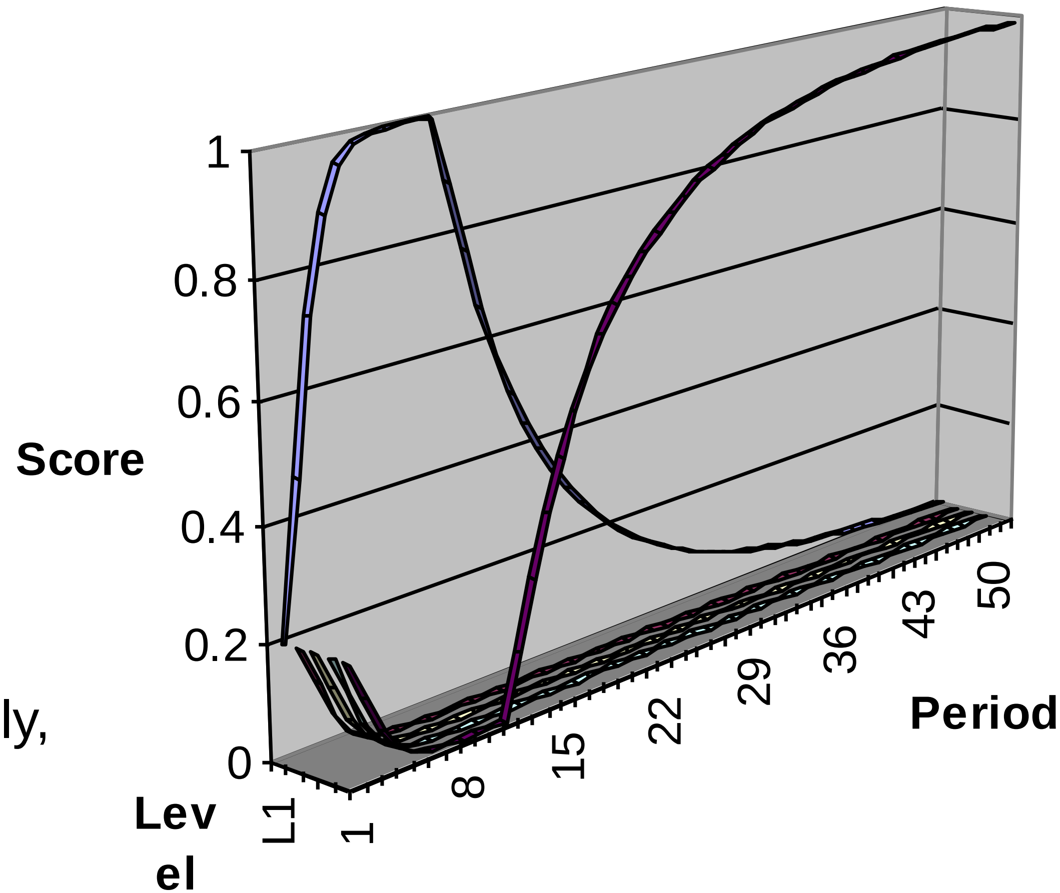
Longevity $\lambda = 0.9$

High longevity $\lambda_H = 0.999$

Base rate $a_{i+1}(Lj) = E_i(Lj)$

Periods 1-10: Mediocre

Periods 11-50: Excellent



The max and min reputation scores are 0 and 1 respectively, and are independent of the longevity factor λ.

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Point Estimate Reputation Score

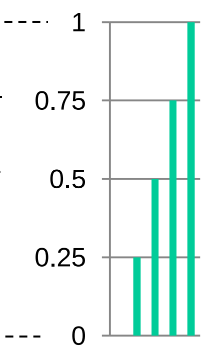
- Useful to have a single-valued score
- Translate multinomial score to point-estimate score

- $v(L_j) = \dfrac{j\text{-}1}{l\text{-}1}$: Point value for each rating level

- $\sigma = \sum_{j=1}^{l} v(L_j) \cdot Sc(L_j)$: Point estimate

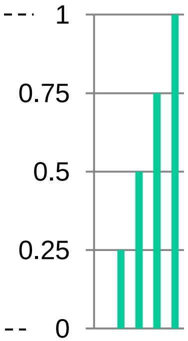
- l : number of rating levels
- j : particular rating level

- Example level values:
  - $v(L_5)=1$
  - $v(L_4)=0.75$
  - $v(L_3)=0.5$
  - $v(L_2)=0.25$
  - $v(L_1)=0$

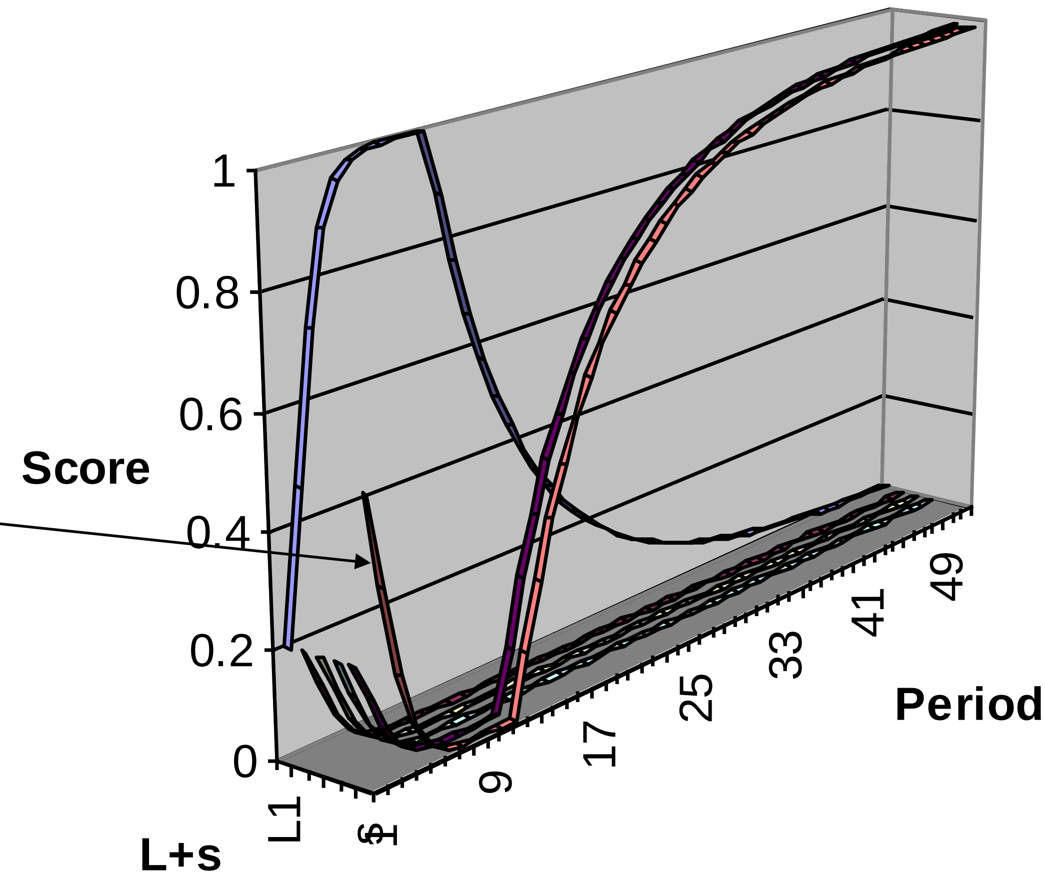


Multinomial score and point estimate with individual base rate

- Level values:
  - $v(L_5)=1$
  - $v(L_4)=0.75$
  - $v(L_3)=0.5$
  - $v(L_2)=0.25$
  - $v(L_1)=0$



- s=σ= point estimate
- Longevity λ= 0.9
- High longevity λ_H= 0.999
- Base rate $a_{i+1}(L_j)= \mathrm{E}_i(L_j)$
- Periods 1-10: Mediocre
- Periods 11-50: Excellent



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Score and point estimate with 5 consecutive uniform rating periods

Longevity λ= 0.9

High longevity λ_H= 0.999

Base rate $a_{i+1}(Lj)= E_i(Lj)$

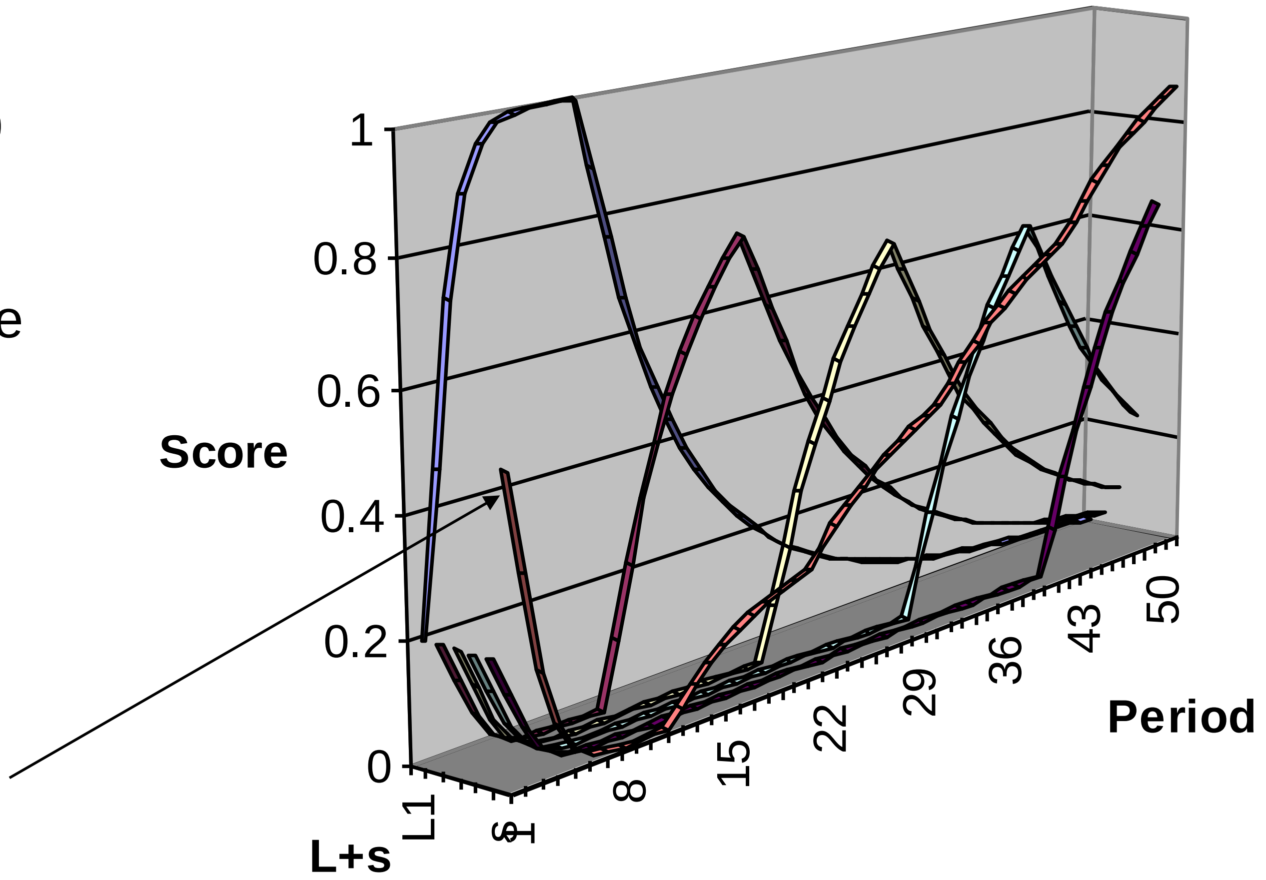
Periods 1-10: Mediocre

Periods 11-20: Bad

Periods 21-30: Medium

Periods 31-40: Good

Periods 41-50: Excellent



•s=σ= point estimate

Discrete models

- Discrete measures
  - *"Very trustworthy", "trustworthy", "untrustworthy"*
- Computation
  - Heuristic formula, or lookup tables
- Simple to understand
- Qualitative
- Theoretically misguided

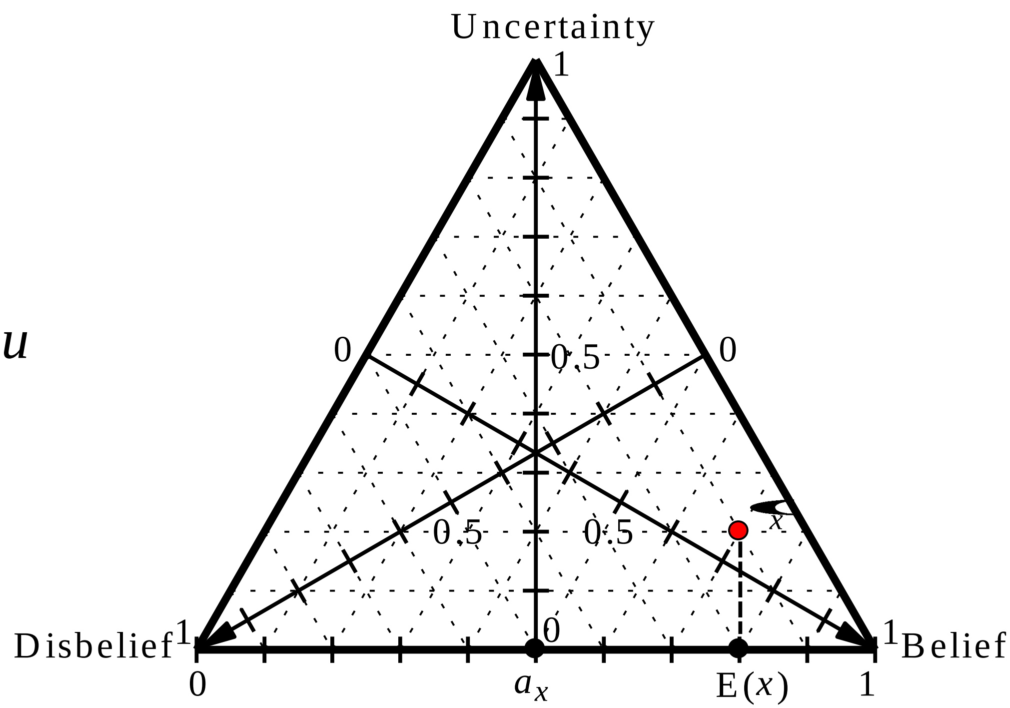
Belief models

- Assumes a trust scope σ
- Two semantic variants of each trust scope
  - Fuctional: Trust x for scope σ
    (e.g. "to be a good mechanic")
  - Referral: Trust x to refer or recommend someone/thing for scope σ
    (e.g. "to be a good at recommending mechanics)
- Two topological types
  - Direct: Trust as a result of direct experience
  - Indirect: Trust as a result of second hand evidence

Computing Trust with Subjective Logic

- Generalization of binary logic and probability calculus.
- Trust represented as binomial opinion: $\omega_x^A = (b, d, u, a)$
  - b: belief
  - d: disbelief
  - u: uncertainty
  - a: base rate

  in range [0,1]
- Where: $b + d + u = 1$
- Expectation value: $E(\omega) = b + au$
- Explicit belief ownership.



Subjective logic operators 1

Opinion operator name	**Opinion operator symbol**	**Logic operator symbol**	**Logic operator name**
Addition	+	$\cup$	UNION
Subtraction	-	\	DIFFERENCE
Complement	¬	$\overline{x}$	NOT
Expectation	E(x)	n.a.	n.a.
Multiplication	·	$\wedge$	AND
Division	/	$\overline{\wedge}$	UN-AND
Comultiplication	$\sqcup$	$\vee$	OR
Codivision	$\overline{\sqcup}$	$\overline{\vee}$	UN-OR

Subjective logic operators 2

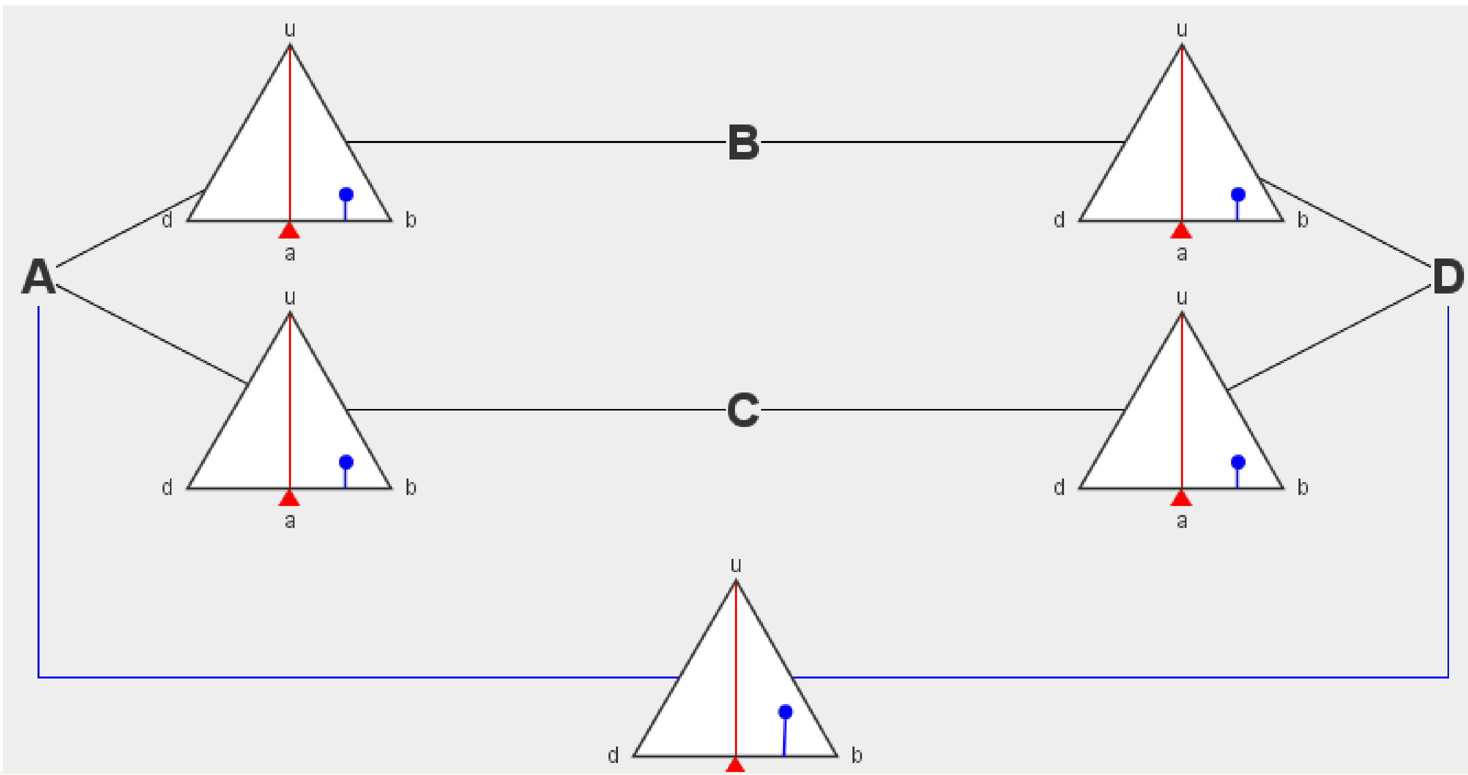
Opinion operator name	Opinion operator symbol	Logic operator symbol	Logic operator name
Discounting	$\otimes$	$:$	TRANSITIVITY
Consensus	$\oplus$	$\lozenge$	FUSION
Conditional deduction	$\circledcirc$	$\|$	DEDUCTION (Modus Ponens)
Conditional abduction	$\overline{\circledcirc}$	$\overline{\|}$	ABDUCTION (Modus Tollens)

Example belief model

Simple Trust Network Demo

Four entities, labelled **A**, **B**, **C** and **D** have opinios about each other represented as points in triangles. Entity **A** is trying to form an opinion about **D**, and receives opinions from **B** and **C** as to the trustworthiness of **D**. Furthermore, **A** has his own opinions about the trustworthiness of **B** and **C**.

Left-click and drag opinion points to set opinion values. Entity **A** combines these opinions using the Subjective Logic Operators to derive his own opinion about **D**, as shown by the bottom opinion triangle. In detail, entity **A** *discounts* **B**'s opinion about **D** by his opinion about **B**, and does similarly for **C**. Finally, he combines the two discounted opinions using the *consensus* operator in order to determine his opinion about **D**. Right-click on the opinion triangles to see the exact values of each opinion. Opinion values can also be visualised using three-coloured rectangles.



Flow models

- Transitive iteration through graph
- Loops and arbitrarily long paths
- Source of trust can be distributed
  - evenly, e.g. early version of PageRank
  - discretely, e.g. current PageRank, EigenTrust
- Sum of trust can be
  - constant, e.g. PageRank
  - increasing with network size, e.g. EigenTrust

Google's PageRank

- Purpose to provide quality search results
- Based on:
  - Number of incoming links, weighted by the
  - PageRank of the sites behind incoming links
- Hyperlinks interpreted as positive ratings.
- No negative ratings.
- Random surfer model.
- PageRank is a reputation system

PageRank visualisation

- R(*A*) = (1-*d*)/N(Web) + *d*·ΣR(prev(*A*))/N(next(prev(*A*)))
- Damping factor $d \approx 0.85$
- ΣR(*A*) ≈ 1, i.e. R(*A*) is the probability of the random surfer
- PageRank(*A*) = $l + \log_{\approx 10}$ R(*A*), where $l \approx 11$

Initial rank R

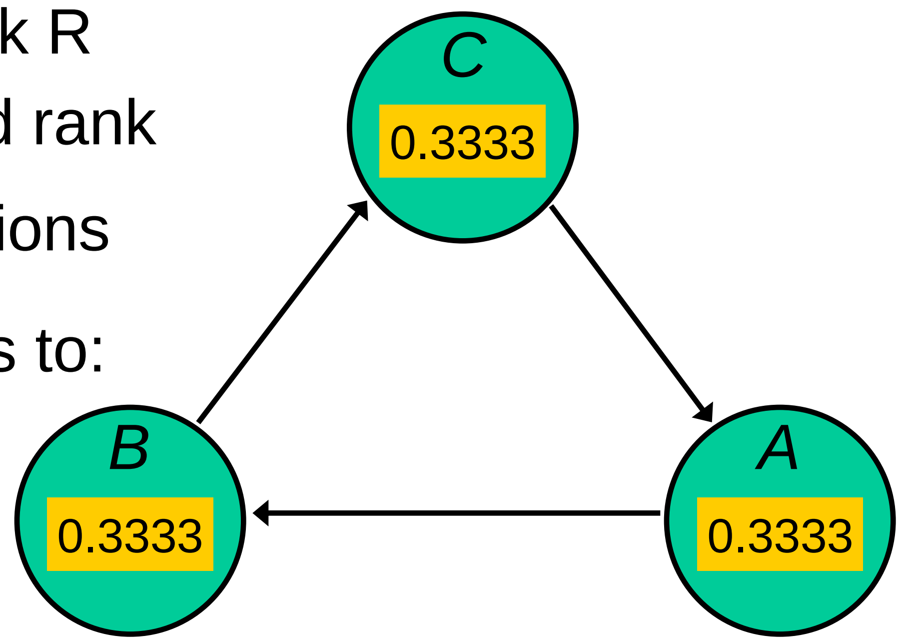
+ imported rank

and iterations

Converges to:

Example

with N(Web)=3



Link spam and "nofollow"

- Survival of e-commerce sites depends on rank
- Attempts to increase rank with link spam
  – consists of putting URLs to own Web site in wikis (publicly editable Web sites) and in postings to public discussion groups
- The "nofollow" tag, introduced in 2005, instructs Web crawlers not to follow a link

```
<a href=http://spam_site.com
 rel="nofollow">Link</a>
```

- Wikis and discussion groups now add "nofollow" to all URLs, thereby eliminating the link spam problem

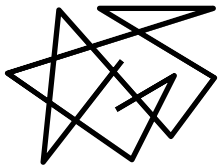
SERP Rank

- SERP: Search Engine Results Page
- SERP Rank: Position of page reference on SERP
- ≠ PageRank
- SERP Rank is a function of PageRank + constantly tuned factors:
  - Keyword position and frequency
  - Linking to good neighbourhoods
  - Freshness
  - etc.

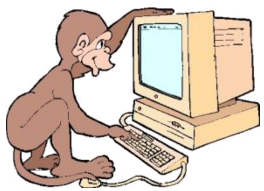
Evolution of web search ranking models

Evolution and time

Increasing quality of Web page ranking



No ranking (Altavista), ca. 1995

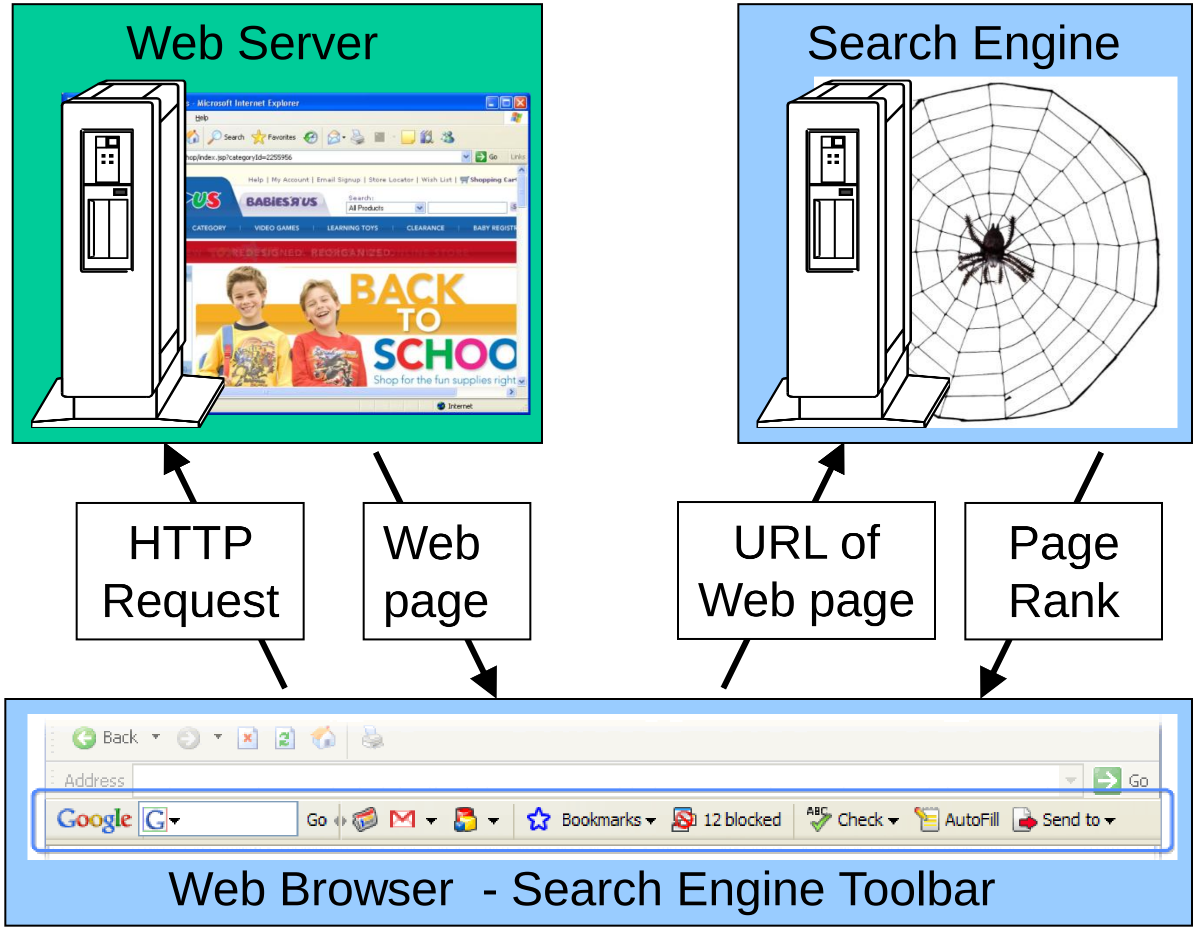


Random surfer model (Google PageRank), ca. 2000

Intentional surfer model (Google Toolbar), ca. 2005

Critical surfer model (Reputation Toolbar), ca. 2010

Browser toolbar architecture



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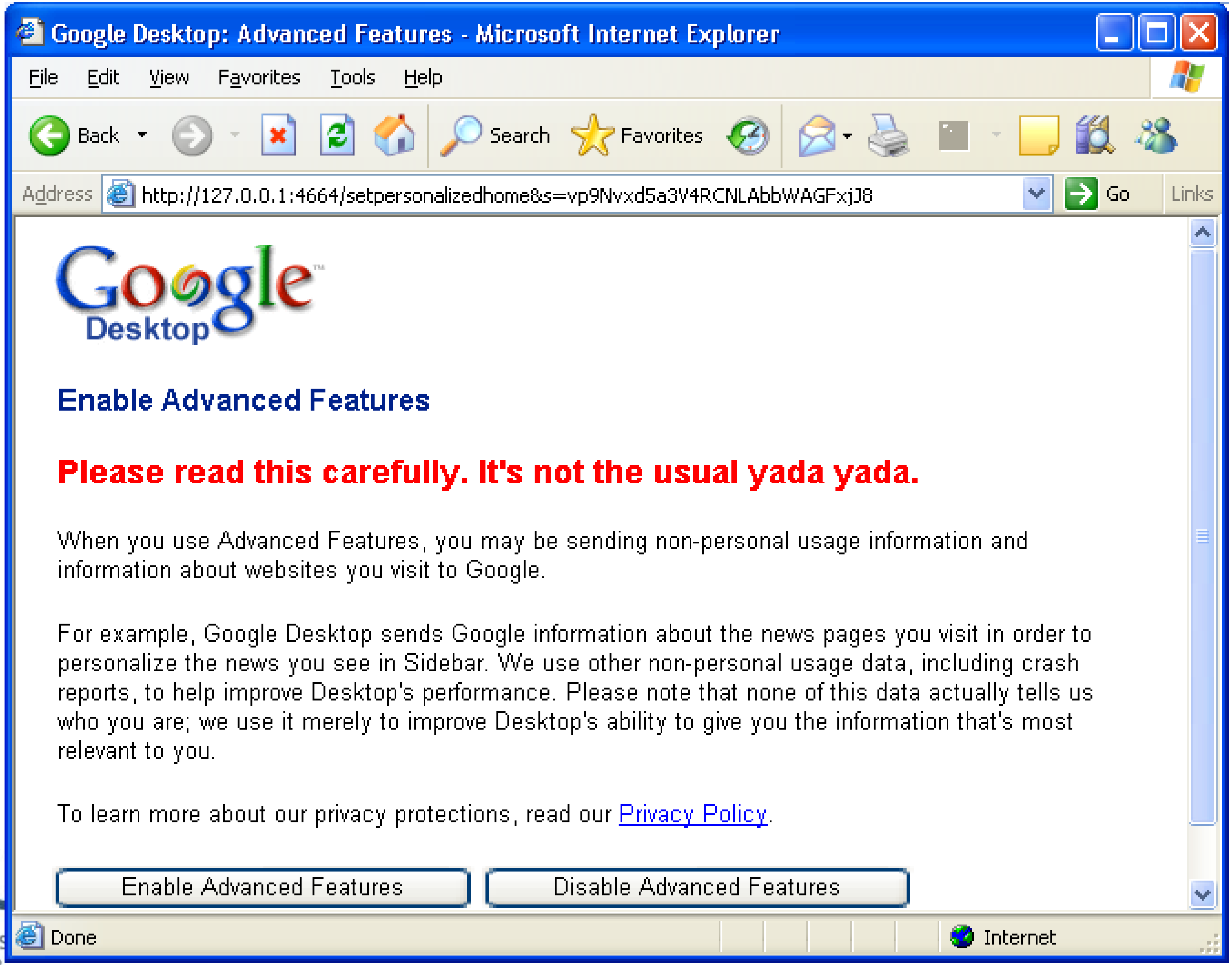
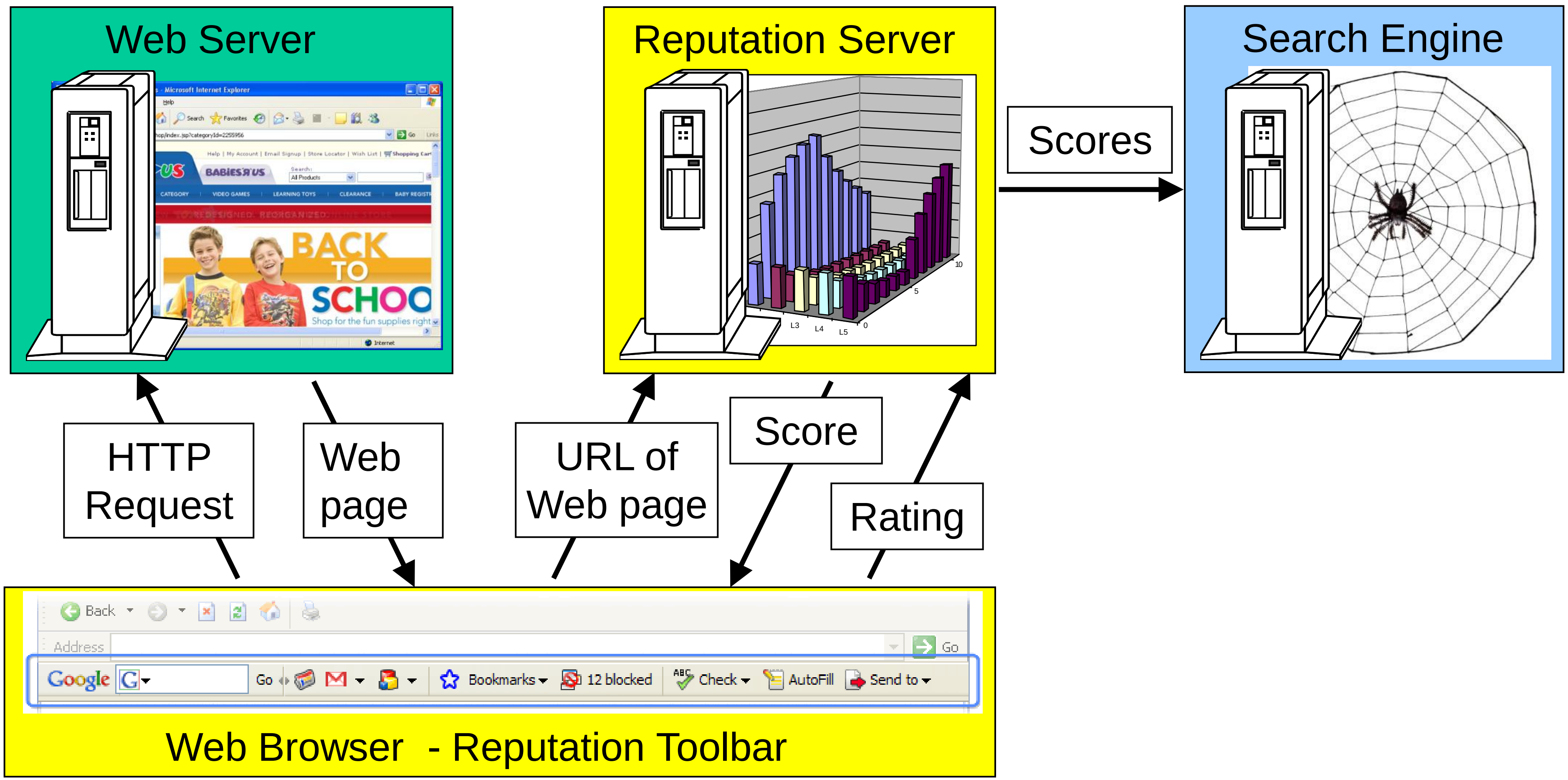
Evidence from toolbars and spyware



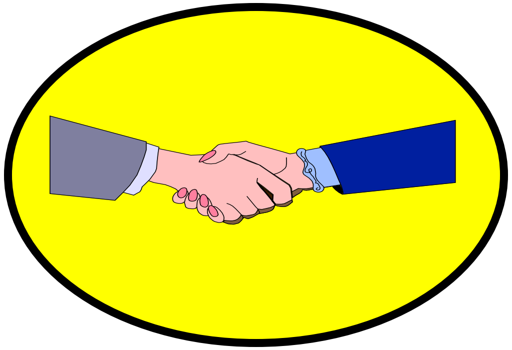
Critical surfer model

- People sometimes access a Web site even though they don't approve of its content
  - e.g. IT security researcher investigating phishing sites
- Critical surfer model depends on people rating Web pages
- Ranking = probability of people accessing a given page, weighted by its reputation score

Critical surfer model implementation



Commercial and online trust and reputation systens



Web Sites with reputation systems

- Auction sites:
  - www.ebay.com
  - auctions.yahoo.com
  - www.amazon.com
- Expert sites
  - www.expertcentral.com
  - www.askme.com
  - www.allexperts.com
- Product reviews
  - www.epinions.com
  - www.amazon.com
- Medical
  - http://www.ratemds.com/
- Article postings
  - www.slashdot.com
  - www.everything2.org
- Education
  - us.ratemyteachers.com
  - www.virtualratings.com
- Entertainment
  - www.citysearch.com
  - www.imdb.com
  - radio.weblogs.com
- e-commerce
  - www.bizrate.com
  - www.virtualratings.com

The eBay Feedback Forum

- Centralised reputation system
- Ratings:
  - Buyers and sellers rate each other, 50% - 60% times
  - positive, negative, neutral, + short comment
- Score = Σ positive - Σ negative
- Time windows
- Surprisingly positive ratings, only 1% negative
- Correlation between seller and buyer ratings
- Many empirical studies
- Purpose: to control the quality of market

Example eBay member's profile

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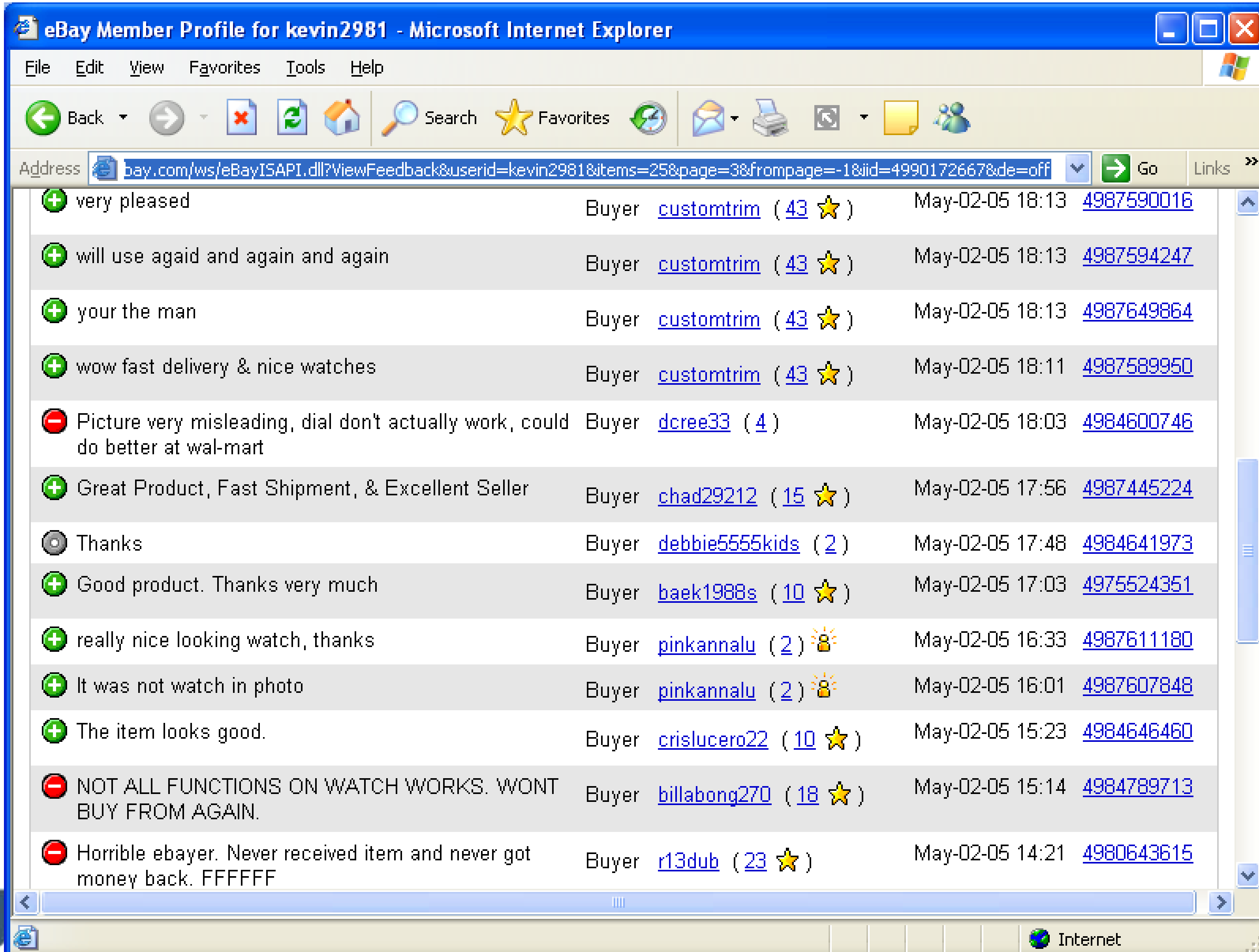
Example eBay feedback comments


eBay Member Profile for kevin2981 - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address bay.com/ws/eBayISAPI.dll?ViewFeedback&userid=kevin2981&items=25&page=3&frompage=-1&iid=4990172667&de=off

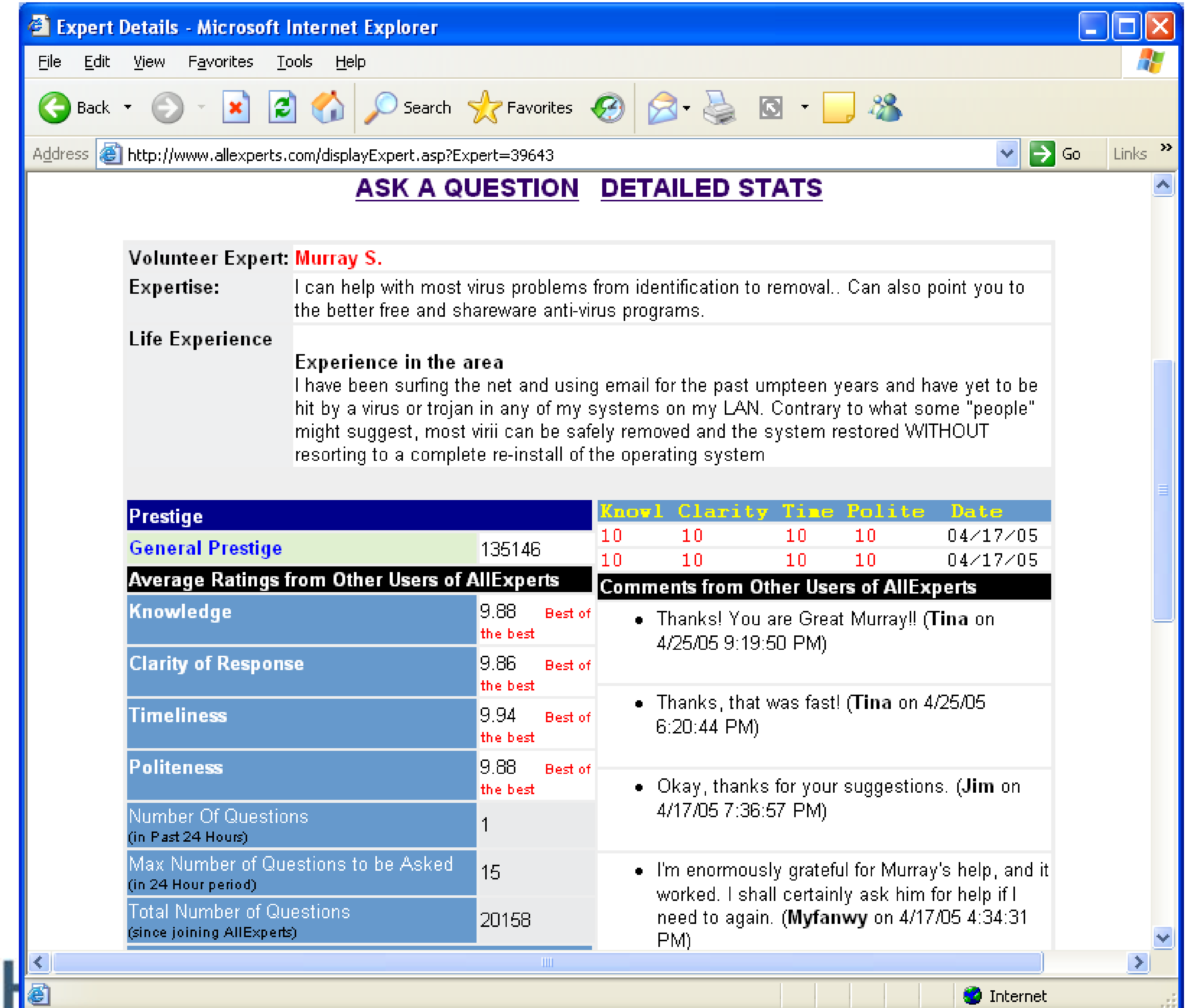
very pleased	Buyer	customtrim (43)	May-02-05 18:13	4987590016
will use agaid and again and again	Buyer	customtrim (43)	May-02-05 18:13	4987594247
your the man	Buyer	customtrim (43)	May-02-05 18:13	4987649864
wow fast delivery & nice watches	Buyer	customtrim (43)	May-02-05 18:11	4987589950
Picture very misleading, dial don't actually work, could do better at wal-mart	Buyer	dcree33 (4)	May-02-05 18:03	4984600746
Great Product, Fast Shipment, & Excellent Seller	Buyer	chad29212 (15)	May-02-05 17:56	4987445224
Thanks	Buyer	debbie5555kids (2)	May-02-05 17:48	4984641973
Good product. Thanks very much	Buyer	baek1988s (10)	May-02-05 17:03	4975524351
really nice looking watch, thanks	Buyer	pinkannalu (2)	May-02-05 16:33	4987611180
It was not watch in photo	Buyer	pinkannalu (2)	May-02-05 16:01	4987607848
The item looks good.	Buyer	crislucero22 (10)	May-02-05 15:23	4984646460
NOT ALL FUNCTIONS ON WATCH WORKS. WONT BUY FROM AGAIN.	Buyer	billabong270 (18)	May-02-05 15:14	4984789713
Horrible ebayer. Never received item and never got money back. FFFFFF	Buyer	r13dub (23)	May-02-05 14:21	4980643615

Internet

AllExperts

- Free advice from volunteer experts
- Ratings given on scale [1,10] for
  - Knowledgeable, Clarity of response, Timeliness and Politeness
- Score = average of ratings
- Most experts have scores ≈ 10
- Business model:
  - Low profile advertisement
  - Prestige to volunteer experts

Example AllExperts profile

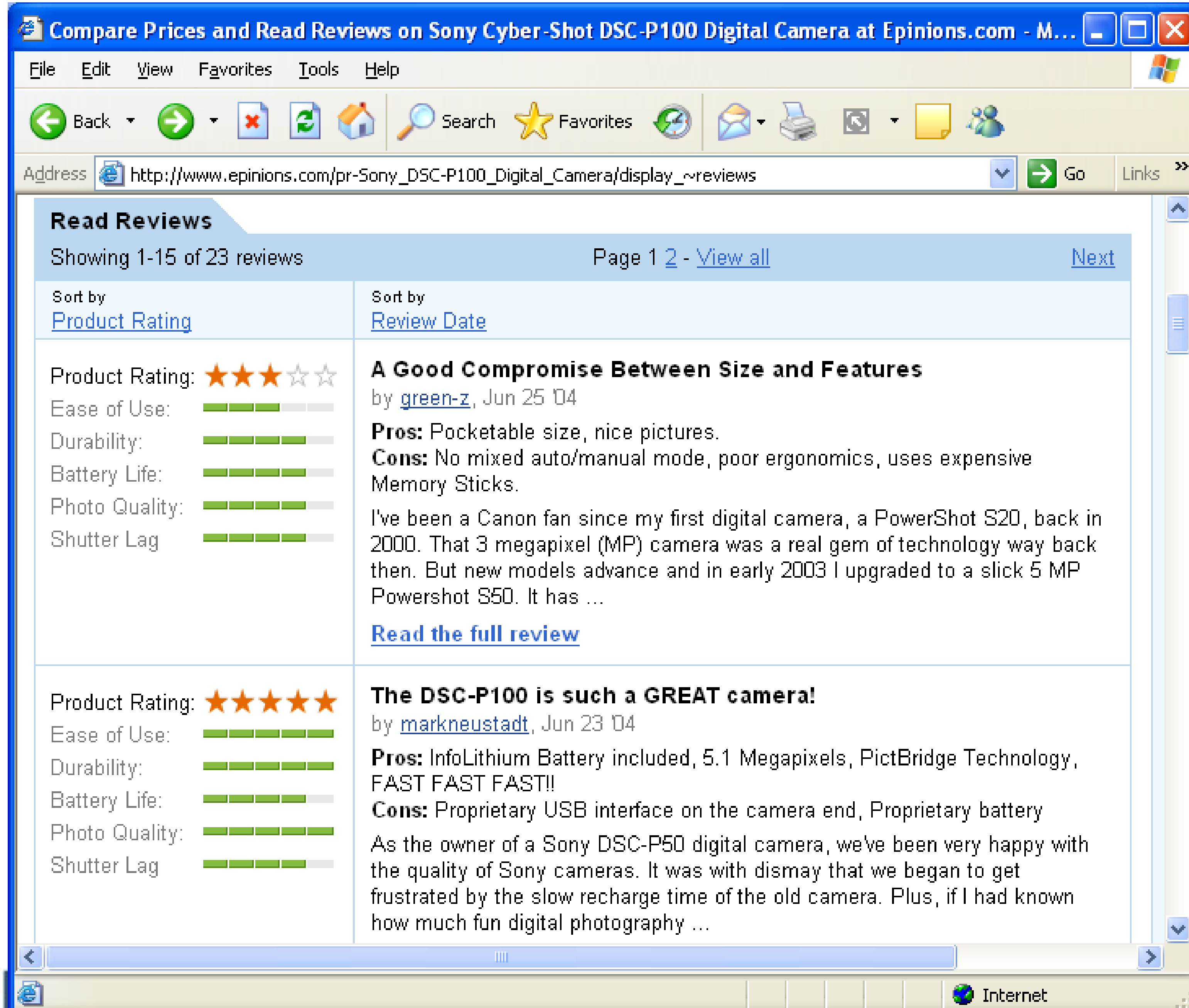


Epinions product review site

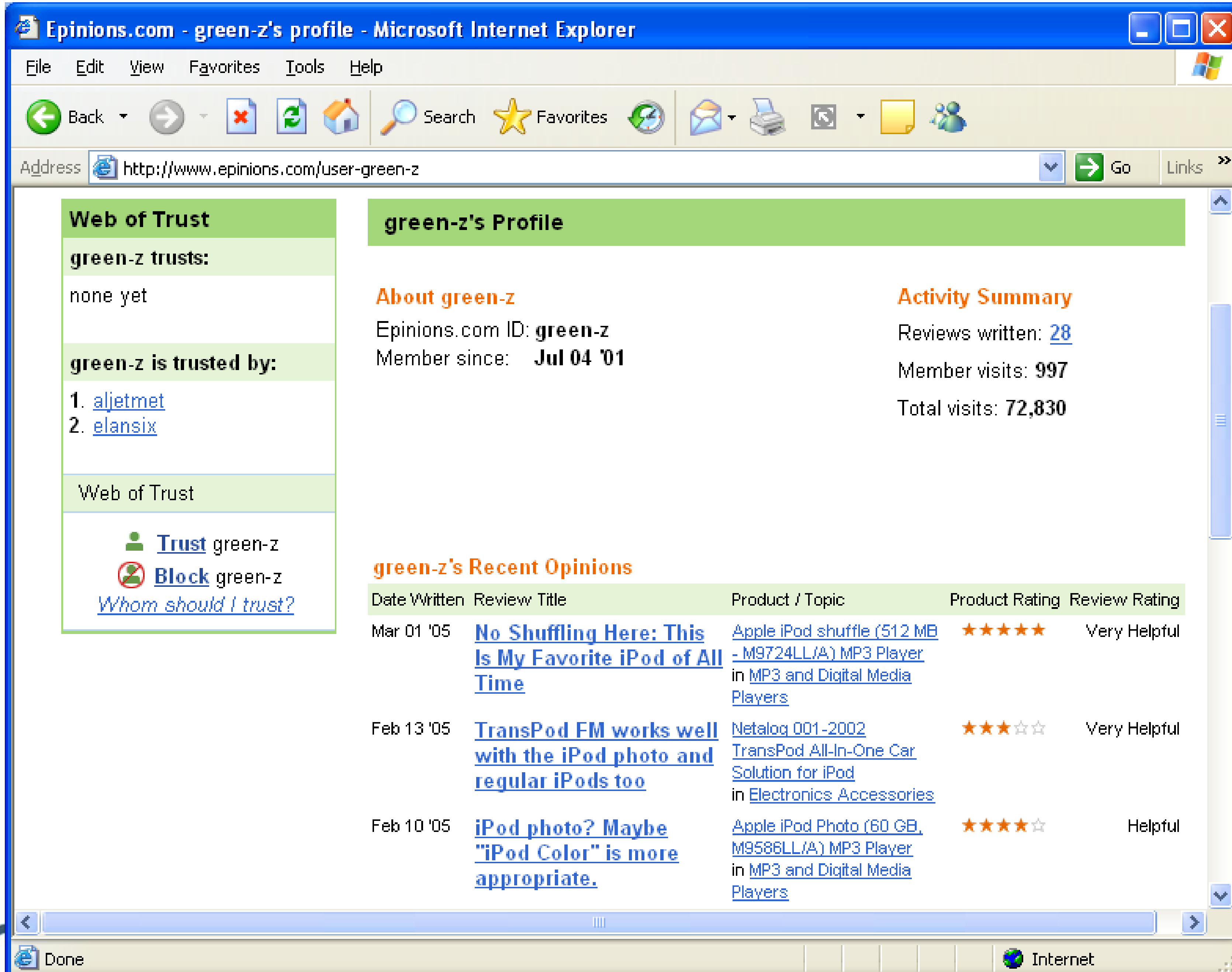
- Reviews consumer products
- Product ratings
  - in range 1 – 5 stars
  - Score = average of product ratings
- Review ratings
  - Not helpful, somewhat helpful, helpful, very helpful
  - Review score = average of review ratings
- Reviewer status
  - Member, advisor, top reviewer, category lead
- Income share program
  - Gives cash to reviewers with high number of very helpful reviews

Example Epinions product profile

Example Epinions product reviews



Example Epinions member

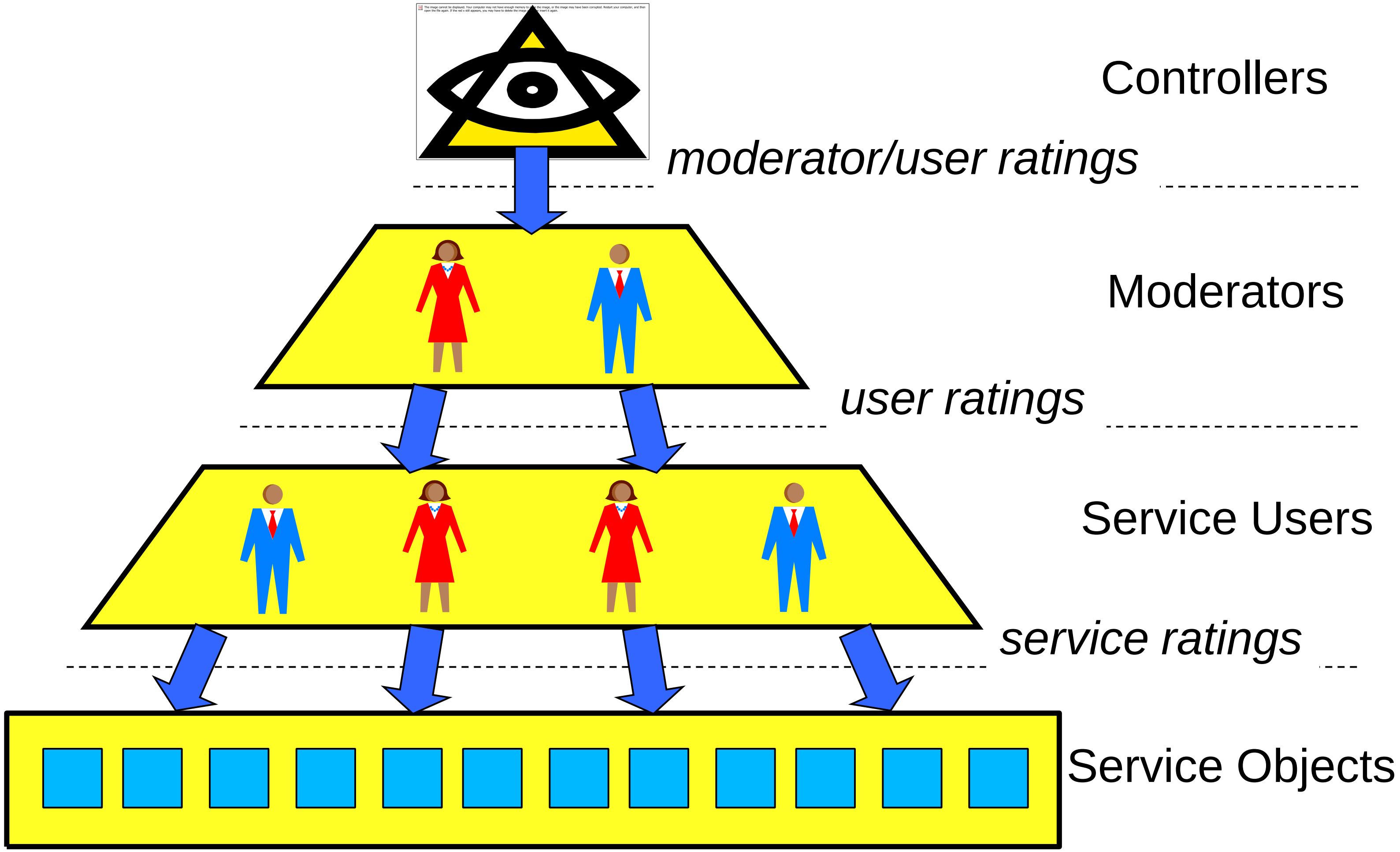


Slashdot

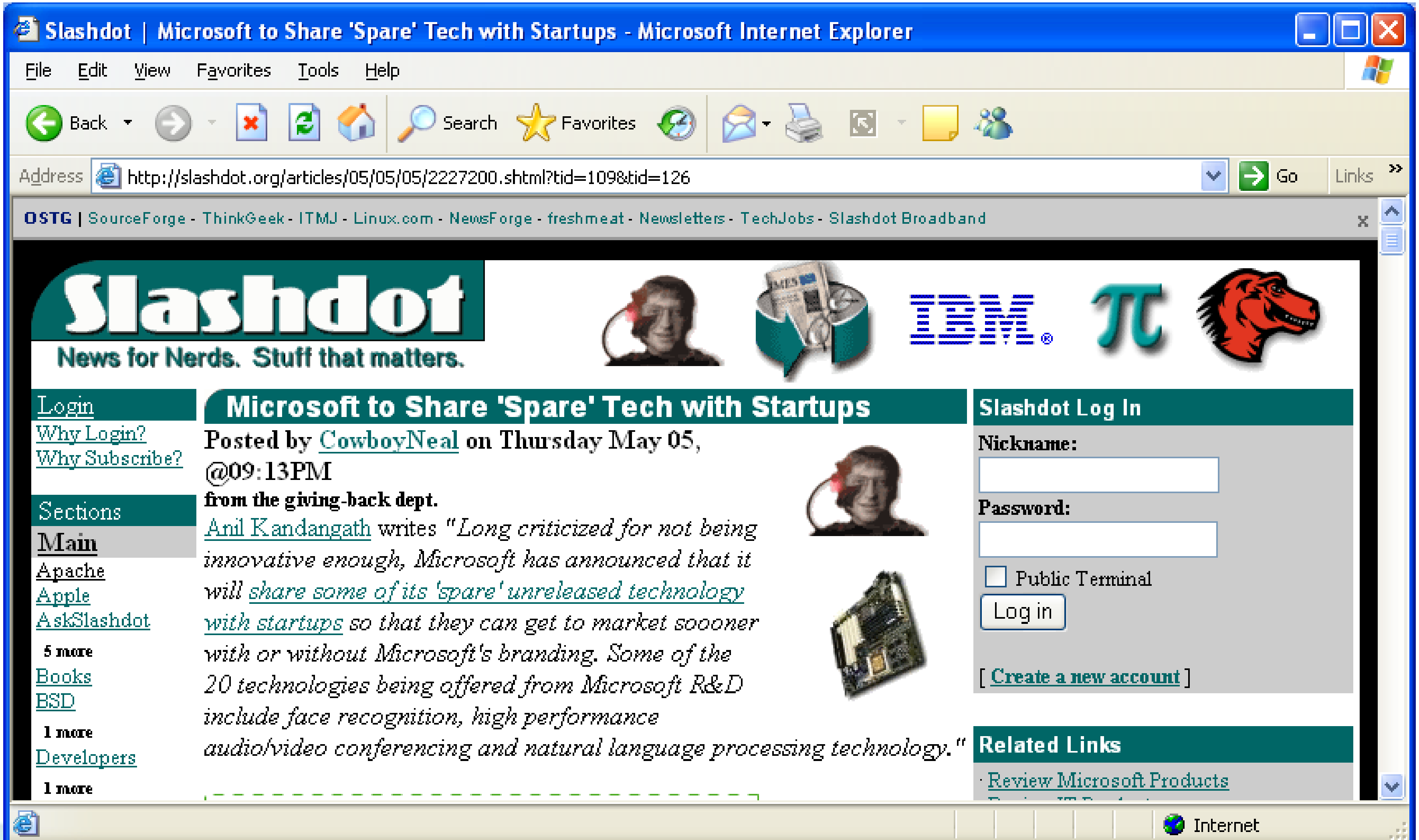
- *“News for nerds”* message board
- Article postings, at Shlasdot’s discretion
- Comments to articles posted by members
- Comment moderation by members
  - Positive: insightful, interesting, informative funny, underrated
  - Negative: offtopic, flamebait, troll, redundant, overrated
  - Comment score ≈ Σ positive(Karma) - Σ negative(Karma),
  - Moderation by members with high Karma carries more weight
- Comment viewing filtered by score
- Member Karma
  - Terrible, bad, neutral, positive, good, excellent
  - Based on moderation of comments.
- Metamoderation, to combat unfair moderation
  - Rate the moderations: fair, unfair, neutral
  - Affects Karma of member who gave the moderation
- Arbitrary moderation by Shlashdot staff
- Purpose: Directing massive collaborative moderation effort

Hierarchic reputation architecture

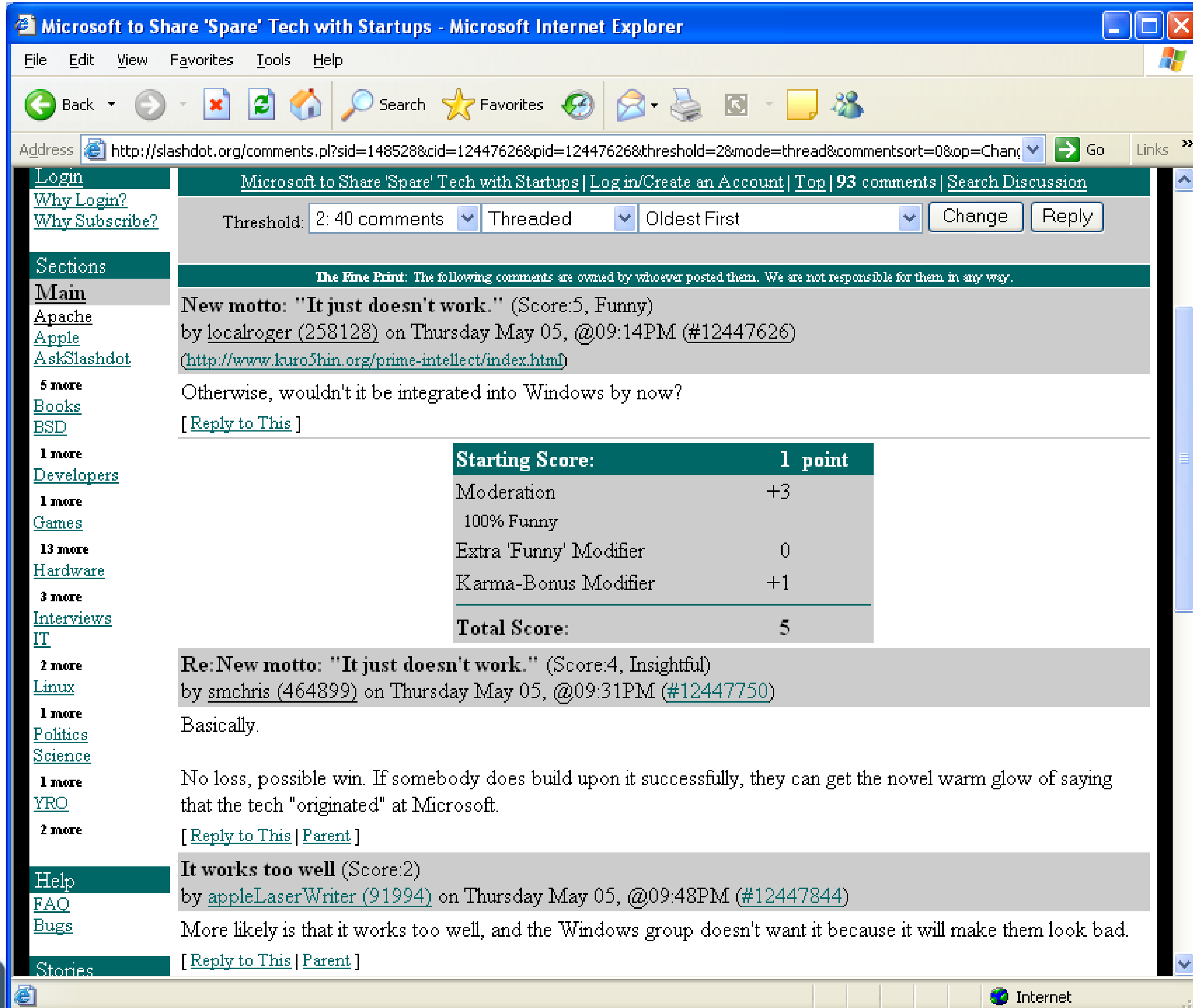
Shlashdot model



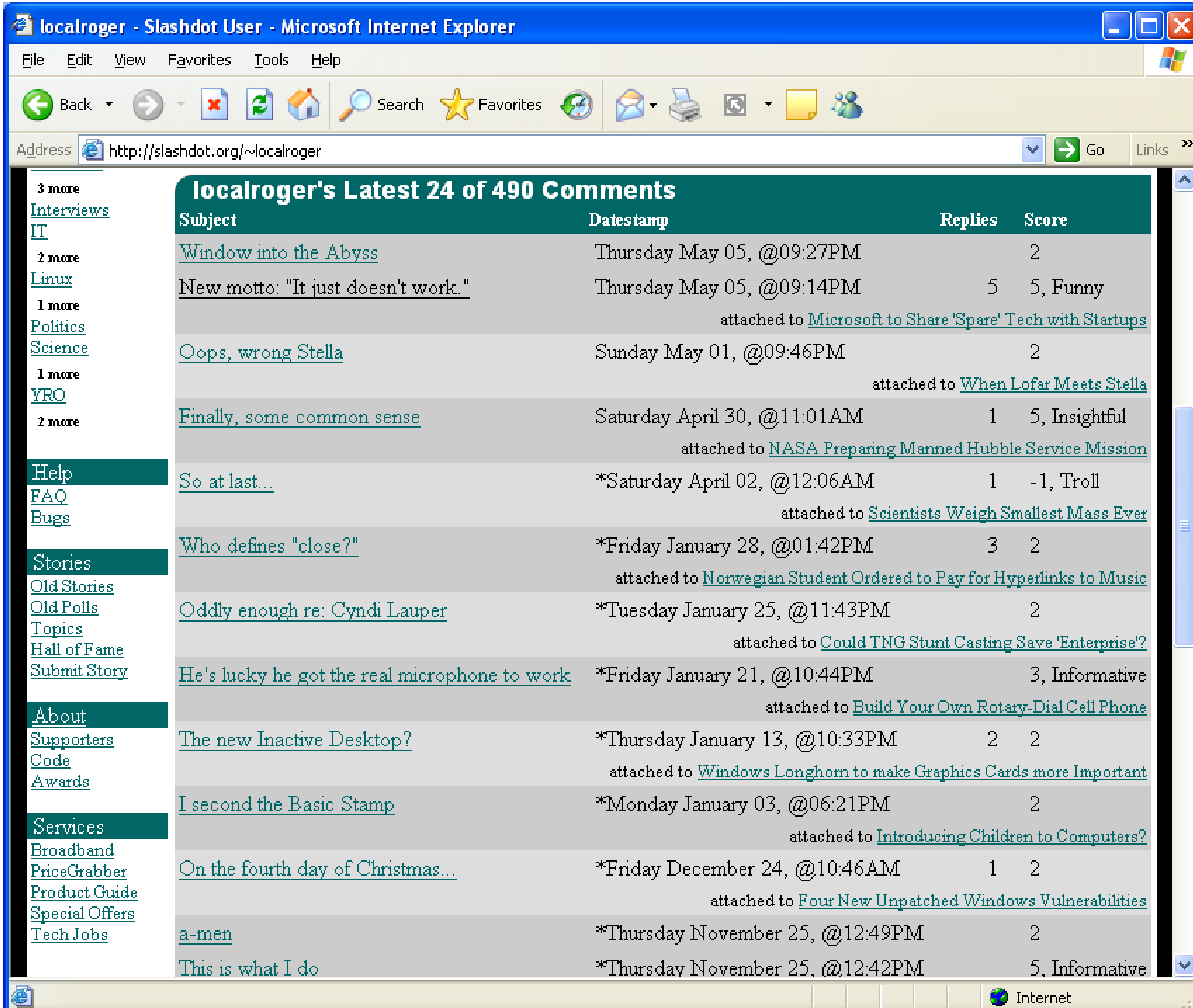
Example Slashdot posting



Example Slashdot comments



Example Slashdot member



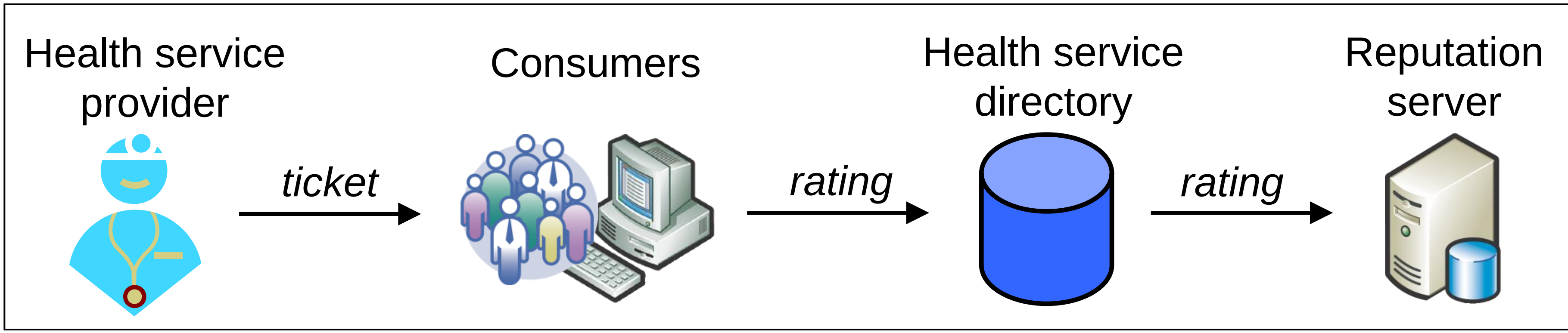
localroger's Latest 24 of 490 Comments

Subject	Datestamp	Replies	Score
Window into the Abyss	Thursday May 05, @09:27PM		2
New motto: "It just doesn't work."	Thursday May 05, @09:14PM	5	5, Funny
	attached to Microsoft to Share 'Spare' Tech with Startups		
Oops, wrong Stella	Sunday May 01, @09:46PM		2
	attached to When Lofar Meets Stella		
Finally, some common sense	Saturday April 30, @11:01AM	1	5, Insightful
	attached to NASA Preparing Manned Hubble Service Mission		
So at last...	*Saturday April 02, @12:06AM	1	-1, Troll
	attached to Scientists Weigh Smallest Mass Ever		
Who defines "close?"	*Friday January 28, @01:42PM	3	2
	attached to Norwegian Student Ordered to Pay for Hyperlinks to Music		
Oddly enough re: Cyndi Lauper	*Tuesday January 25, @11:43PM		2
	attached to Could TNG Stunt Casting Save 'Enterprise'?		
He's lucky he got the real microphone to work	*Friday January 21, @10:44PM		3, Informative
	attached to Build Your Own Rotary-Dial Cell Phone		
The new Inactive Desktop?	*Thursday January 13, @10:33PM	2	2
	attached to Windows Longhorn to make Graphics Cards more Important		
I second the Basic Stamp	*Monday January 03, @06:21PM		2
	attached to Introducing Children to Computers?		
On the fourth day of Christmas...	*Friday December 24, @10:46AM	1	2
	attached to Four New Unpatched Windows Vulnerabilities		
a-men	*Thursday November 25, @12:49PM		2
This is what I do	*Thursday November 25, @12:42PM		5, Informative

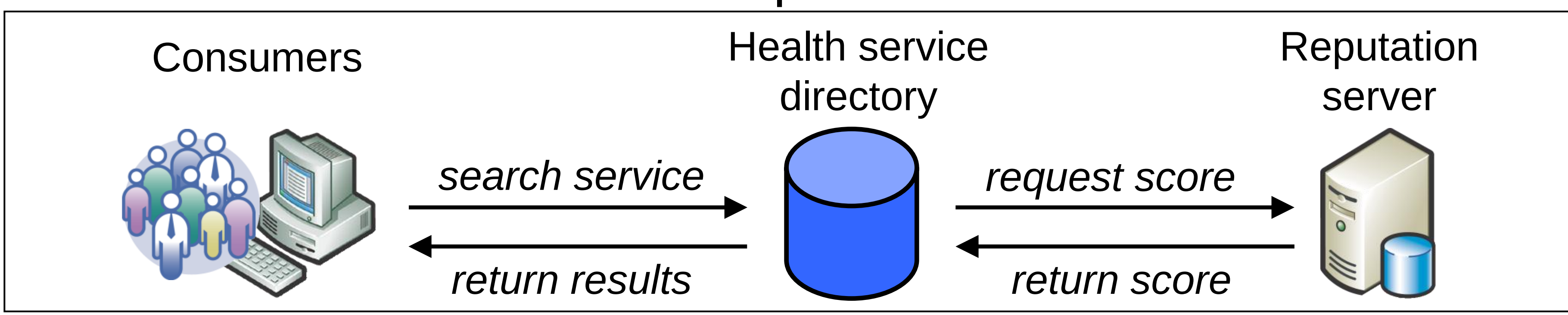
Online reputation for physical services

Architecture for health reputation system

Rating phase



Search phase



Problems and proposed solutions

Reputation System Challenges

- Ad hoc computation
- Playbooks
- Unfair ratings
- Discrimination
- Collusion
- Proliferation
- Reputation lag
- Re-entry/Change of identity
- Value imbalance
- No incentive to provide ratings
- Hard to elicit negative feedback

Unfair/False Ratings

- Amazon.com revealed true identities of reviewers by mistake in 2004
  - Reviews & ratings were written by authors/publishers/competitors
- Political campaigns promote positive and hide negative video clips on YouTube by unfair ratings
  - Use programs that mimic legitimate YouTube traffic
  - Botnets are probably being used
- eBay users are buying and selling feedback

What about subjective taste?

- Collaborative Filtering System
  - Assumes different taste
  - Identifies like-minded with same taste
  - Recommender systems
- Reputation System
  - Assumes consistent quality judgement
  - Sanctions poor quality
  - “Collaborative Sanctioning System”

Yhprum's Law
(systems that shouldn't work sometimes do)

- People provide ratings despite having no rational incentive to do so.
- Negative ratings are hard to elicit.
- Relatively easy to mount attacks against existing reputation systems.

- A reputation system works when people can relate to it
- Supports community building

Countermeasures against attacks

- Sound computation engines
- Authentication/security
  - Prevents change of identity
- Statistical filtering, and discounting
  - To prevent unfair ratings, discrimination and collusion
- Multilevel moderation
  - More difficult to manipulate
- Anonymity
  - To prevent fear of retaliation
- Benefits / special offers
  - To provide incentive

Concluding remarks

- Commercial online systems use very primitive computation engines
  - Advantage that users understand the systems, but
  - Usually not robust against attacks
- Many different proposed theoretic systems
  - Little coherence among researchers
  - No single system is optimal for all applications
- Validation of reputation system robustness
  - Simulation of limited value
  - Must be tried in the live
- Value of reputation systems is more than scores
  - Lets people relate to each other
  - Social glue
  - Catalyst for creating thriving communities