



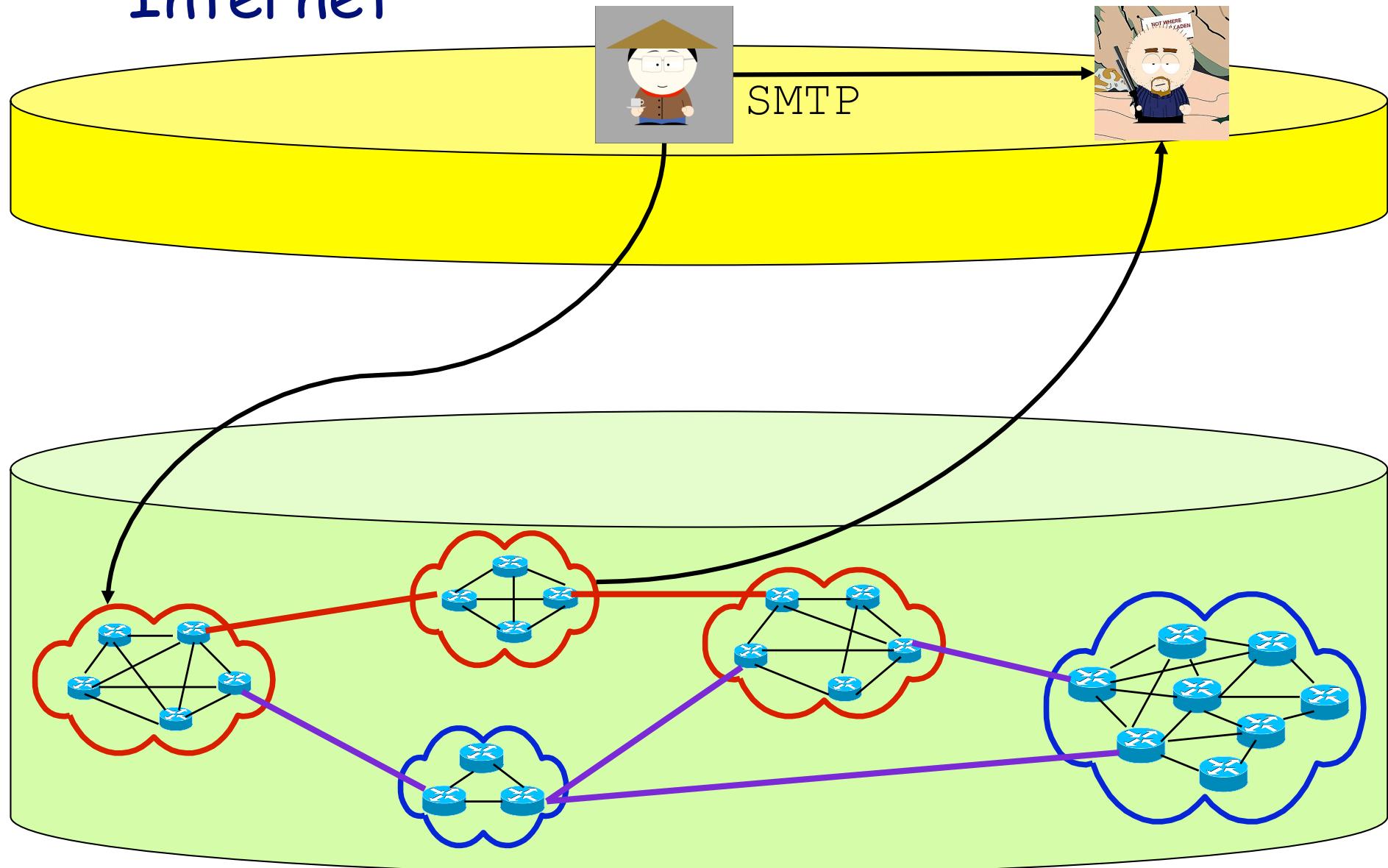
Davis Social Links

Social Network Kernel for Future Internet Design

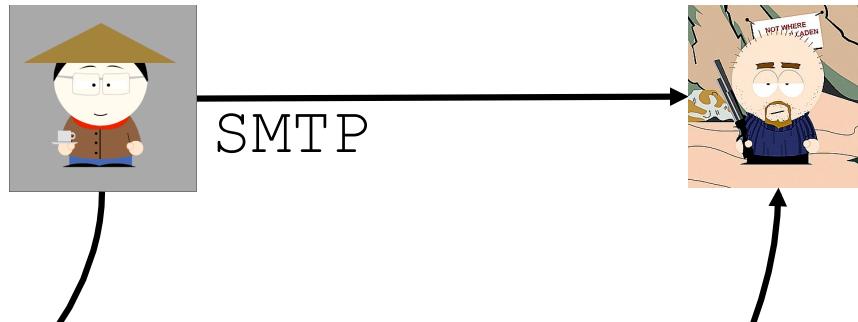
Lerone Banks, Prantik Bhattachayya, Matt Spear, S. Felix Wu,
Computer Science, University of California, Davis

<http://www.facebook.com/people/sfelixwu/>

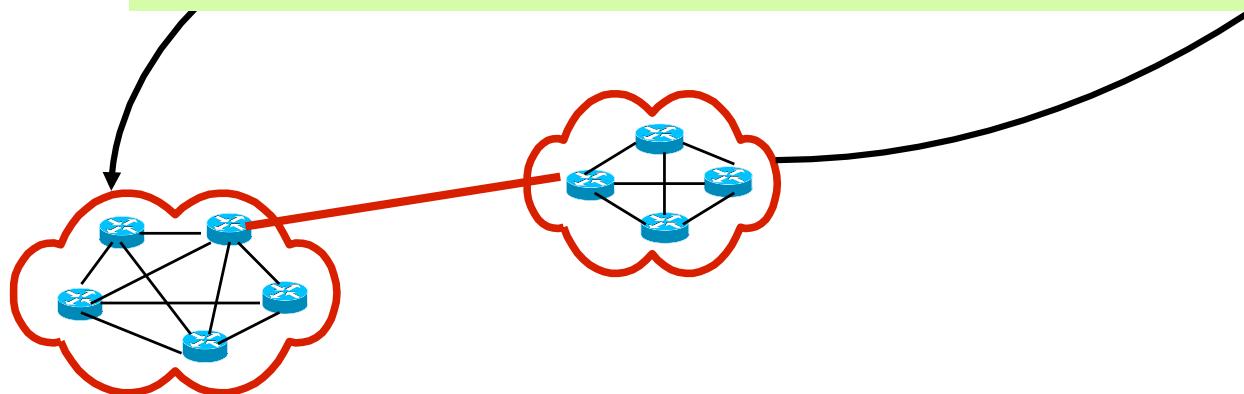
Internet



Routable Identity



- Any identity (email address, IP, url) can communicate with any one else.
 - Email, web, bittorrent, warcraft, skype...



FROM:MR.CHEUNG PUI
 Hang Seng Bank Ltd
 Sai Wan Ho Branch
 171 Shaukiwan Road
 Hong Kong.



Please contact me on my personal box [puicheungcheungpui@yahoo.com]
 Let me start by introducing myself. I am Mr. Cheung Pui, director of operations of the Hang Seng Bank Ltd, Sai Wan Ho Branch. I have a obscured business suggestion for you.

Before the U.S and Iraqi war our client Major Fadi Basem who was with the Iraqi forces and also business man made a numbered fixed deposit for 18 calendar months, with a value of Twenty Four millions Five Hundred Thousand United State Dollars only in my branch. Upon maturity several notice was sent to him,...



CHOICEMAIL

iHateSpam

ca


Qurb




sendio
FOR A SPAM FREE WORLD

SPAMBUSTER

 Tumbleweed®

**Free Spam
Filter**

SPAMfighter

For Outlook and
Express. Enjoy spam
free email now!


BorderWare™

proofpoint


MIRAPPOINT®


BARRACUDA
NETWORKS



CLOUDMARK
AntiSpam

UCDAVIS
UNIVERSITY OF CALIFORNIA


Davis
California

Cost of False Positives

- Spam-filters have to be conservative...
- We will have some false negatives in our own inboxes.
- We will use our own time to further filter..
 - For me, 1~2 seconds per email



The emails I received typically...

Inbox for wu@cs.ucdavis.edu

Get Mail Write Address Book Reply Reply All Forward Tag Delete Junk Print Back Forward

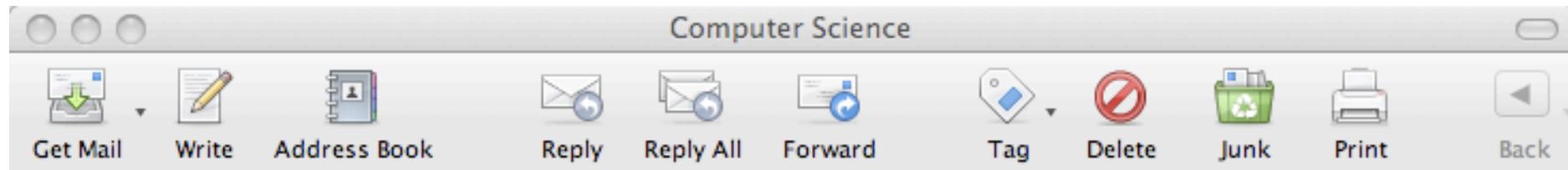
Subject

Sender	Date	Size
Russ Townsley	7:11 AM	3KB
Raquel Silva	8:11 AM	4KB
Rev. Father Jones Maxwell Harth	10:04 AM	3KB
Dr Willy Jorge	11:47 AM	4KB
wangh7@unlv.nevada.edu	2:11 PM	5KB
Mickpamp@aol.com	3:00 PM	13KB
Rotary Foundation International.	3:34 PM	3KB
Fedmarket	9/20/08 3:50 PM	10KB
Anan Martins	9/22/08 1:30 PM	4KB
Audio@HigherEdHero.com	5:59 PM	6KB
Litz Liew (village e-mail)	9/22/08 9:45 AM	8KB
Inventors Expo	7:53 PM	3KB
Jon Rosdahl	6:52 PM	8KB
Jon Rosdahl	7:25 PM	8KB

① Subject: call me on..(+44-704-572-0668)
From: Rev. Father Jones Maxwell Harth <info@revjones.com>
Reply-To: rev.jones.maxwell129@gmail.com
Date: 10:04 AM
Tags: To Do

I am Rev. Father Jones Maxwell Harth, a senior staff with the World Bank fact finding & special duties office. It is better for one to live and die poor honest man than a rich dishonest one. I and the chief security officer (CSO) of this organization have arranged with an officer in computer section engineer Peter Cliff to bring out part of your total pending payment sum amounting to US\$10 million. Why we did this is because according to information gathered from the bank's/security computer, you have been waiting for a long time to receive your money without success. contact email(rev.jones.maxwell129@gmail.com) Tell: +44-704-572-0668.

Unread: 708 Total: 8002



Subject: Computer Science

From: Eric Simich <ericsimich@gmail.com>

Date: 11/27/07 4:38 PM

To: sfwu@ucdavis.edu

Tags: To Do

You have a few seconds to decide.....

Dr. Wu,

My name is Eric Simich, i attend Solano Community College; and, i am very interested in the Computer Science field. One person i know who goes to Davis and is involved in the Computer Science major is Justin Howel, he gave me your url and i took a look at some of the interesting powerpoints and homeworks you had available.

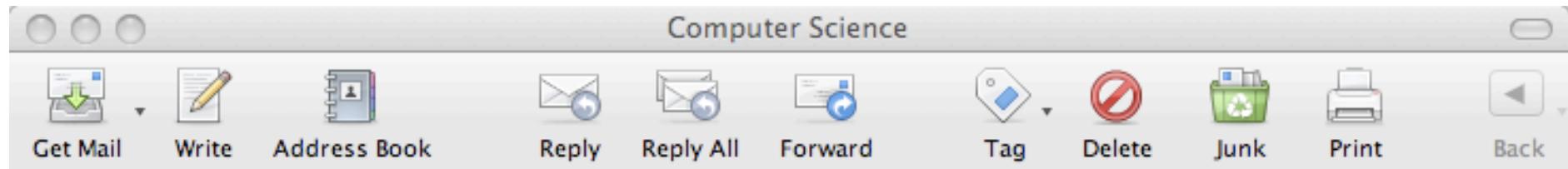
I have had practical and Technical experience(s) involving Computer Science, Theory, and Implementation. I have had real world application(s) in Network Analysis, Security, and System(s) Administration, but i need to get my degree in order to do anything in the larger computer industry.

I am currently a lab aide in the college's computer lab(s). Previous to employment in the lab(s) i was privately contracting myself out to home businesses, the general public, and anyone who had posted for help in forums. I am good at what i do because i have to take caution in my line of work as it is now, i am not A+ certified, or anything! That is why i am going for a degree, i have passion to drive me through school, but i do not have the connections as far as knowing someone within the field itself, or any teachers to give me advice as needed.

I would really like to jump into Computer Science at university level. I am currently finished with General Ed at the college i am attending right now, but i dont have any of the pre-reqs to apply to Davis yet! I would like to get involved in projects or something, just to gain experience and increase my knowledge/passion towards the field itself.

I am willing to do anything!

U Thank you for your time!
UNIVERSITY OF CALIFORNIA



Subject: Computer Science
From: Eric Simich <ericsimich@gmail.com>
Date: 11/27/07 4:38 PM
To: sfwu@ucdavis.edu
Tags: To Do

To me personally, this is a typical social spam.

Dr. Wu,

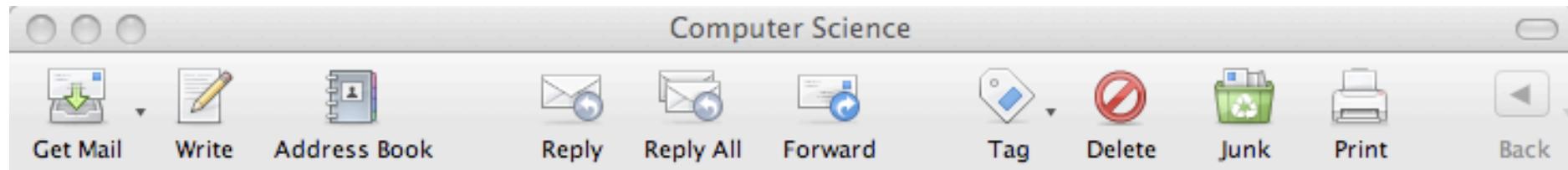
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Date: 11/27/07 4:38 PM

To: sfwu@ucdavis.edu

Tags: To Do

Oops...

Dr. Wu,

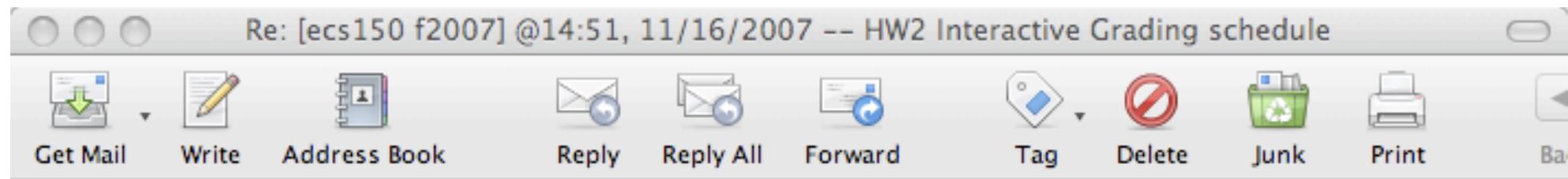
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I am willing to do anything!



Justin Howell, jmhowell@ucdavis.edu, 991347775
Jonathan Counihan, jacounihan@ucdavis.edu, I can get his ID later this evening ...

Justin Howell
Telecommunications Network Technician
-----Original Message-----
From: Felix Wu [<mailto:sfwu@ucdavis.edu>]
Sent: Friday, November 16, 2007 2:57 PM
To: kakkapeddi@ucdavis.edu; gaaldrich@ucdavis.edu; jdallee@ucdavis.edu; mikaltman@ucdavis.edu; sabafico@ucdavis.edu; eddchan@ucdavis.edu; ucdchang@ucdavis.edu; sxchen@ucdavis.edu; sscho@ucdavis.edu; jacounihan@ucdavis.edu; tecrnovrsanin@ucdavis.edu; ogdario@ucdavis.edu; cjdavies@ucdavis.edu; rsdavis@ucdavis.edu; imfont@ucdavis.edu; ahfung@ucdavis.edu; crgilmore@ucdavis.edu; echa@ucdavis.edu; slhitchcock@ucdavis.edu; dahoffman@ucdavis.edu; zlihou@ucdavis.edu; jmhowell@ucdavis.edu; jrisaacson@ucdavis.edu; mtjumper@ucdavis.edu; rwlko@ucdavis.edu; mdlauer@ucdavis.edu; ntlee@ucdavis.edu; aleo@ucdavis.edu:

Re: [ecs150 f2007] @14:51, 11/16/2007 -- HW2 Interactive Grading schedule

Get Mail Write Address Book Reply Reply All Forward Tag Delete Junk Print

Subject: RE: [ecs150 f2007] @14:51, 11/16/2007 – HW2 Interactive Grading schedule
From: Justin Howell <Justin.Howell@solano.edu>
Date: 11/16/07 3:05 PM
To: 'sfwu@ucdavis.edu'

11/27 12/10
/2007 /2007

Hello Prof Wu,

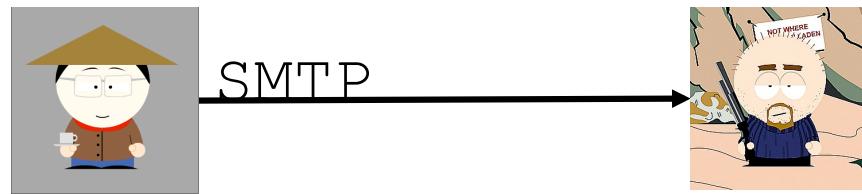
We'd like to sign up for:
11/26 14-15
11/26 11-12

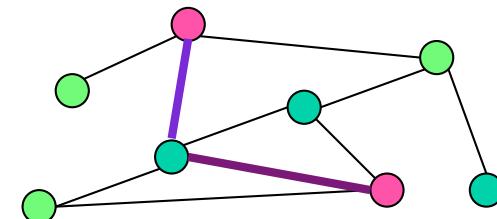
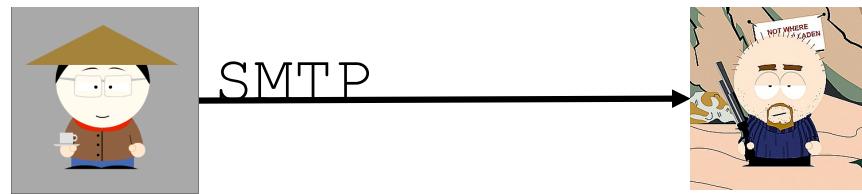
11/16 11/26 Spammed?
/2007 /2007 In my office

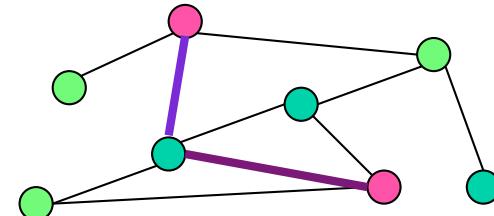
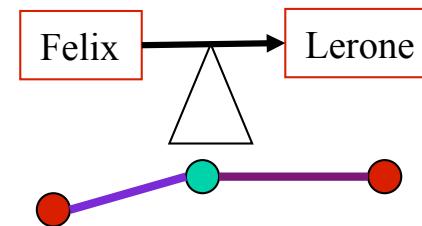
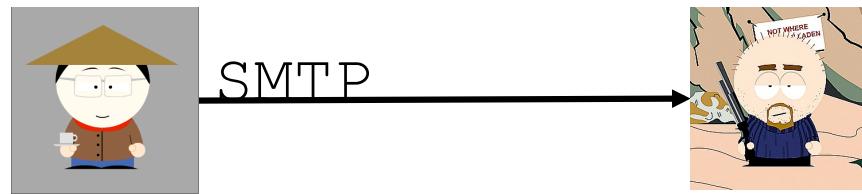
"Memoryless"
For Felix Wu

Justin Howell, jmhowell@ucdavis.edu, 991347775
Jonathan Counihan, jacounihan@ucdavis.edu, I can get his ID later this evening ...

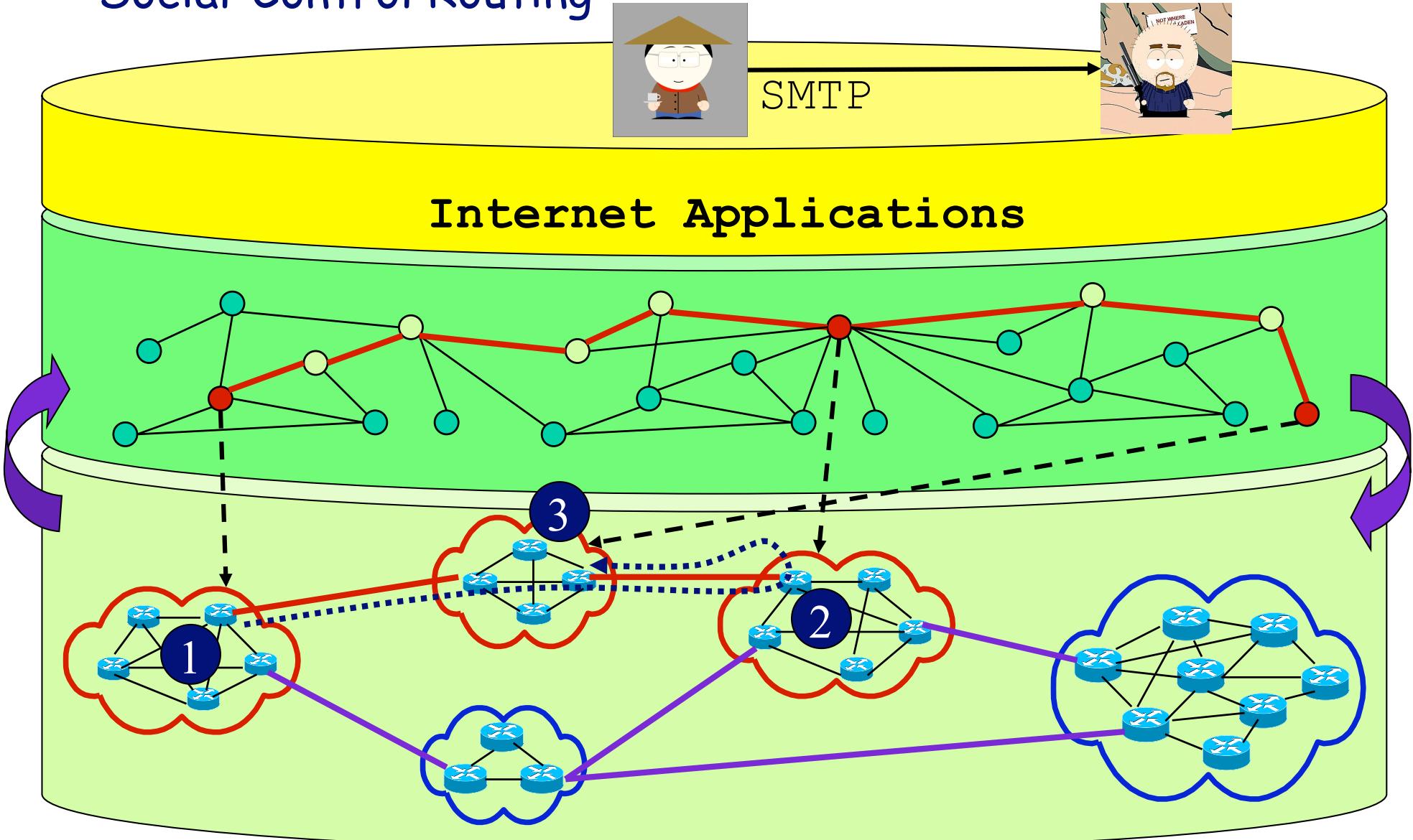
-----Original Message-----
From: Felix Wu [mailto:sfwu@ucdavis.edu]
Sent: Friday, November 16, 2007 2:57 PM
To: kakkapeddi@ucdavis.edu; gaaldrich@ucdavis.edu; jdallee@ucdavis.edu; mikaltman@ucdavis.edu; sabafico@ucdavis.edu; eddchan@ucdavis.edu; ucdchang@ucdavis.edu; sxchen@ucdavis.edu; sscho@ucdavis.edu; jacounihan@ucdavis.edu; tecrnovrsanin@ucdavis.edu; ocdario@ucdavis.edu; cjdavies@ucdavis.edu; rsdavis@ucdavis.edu; imfont@ucdavis.edu; ahfung@ucdavis.edu; crgilmore@ucdavis.edu; echa@ucdavis.edu; slhitchcock@ucdavis.edu; dahoffman@ucdavis.edu; zlihou@ucdavis.edu; jmhowell@ucdavis.edu; jrisaacson@ucdavis.edu; mtjumper@ucdavis.edu; rwlko@ucdavis.edu; mdlauer@ucdavis.edu; ntlee@ucdavis.edu; aleo@ucdavis.edu



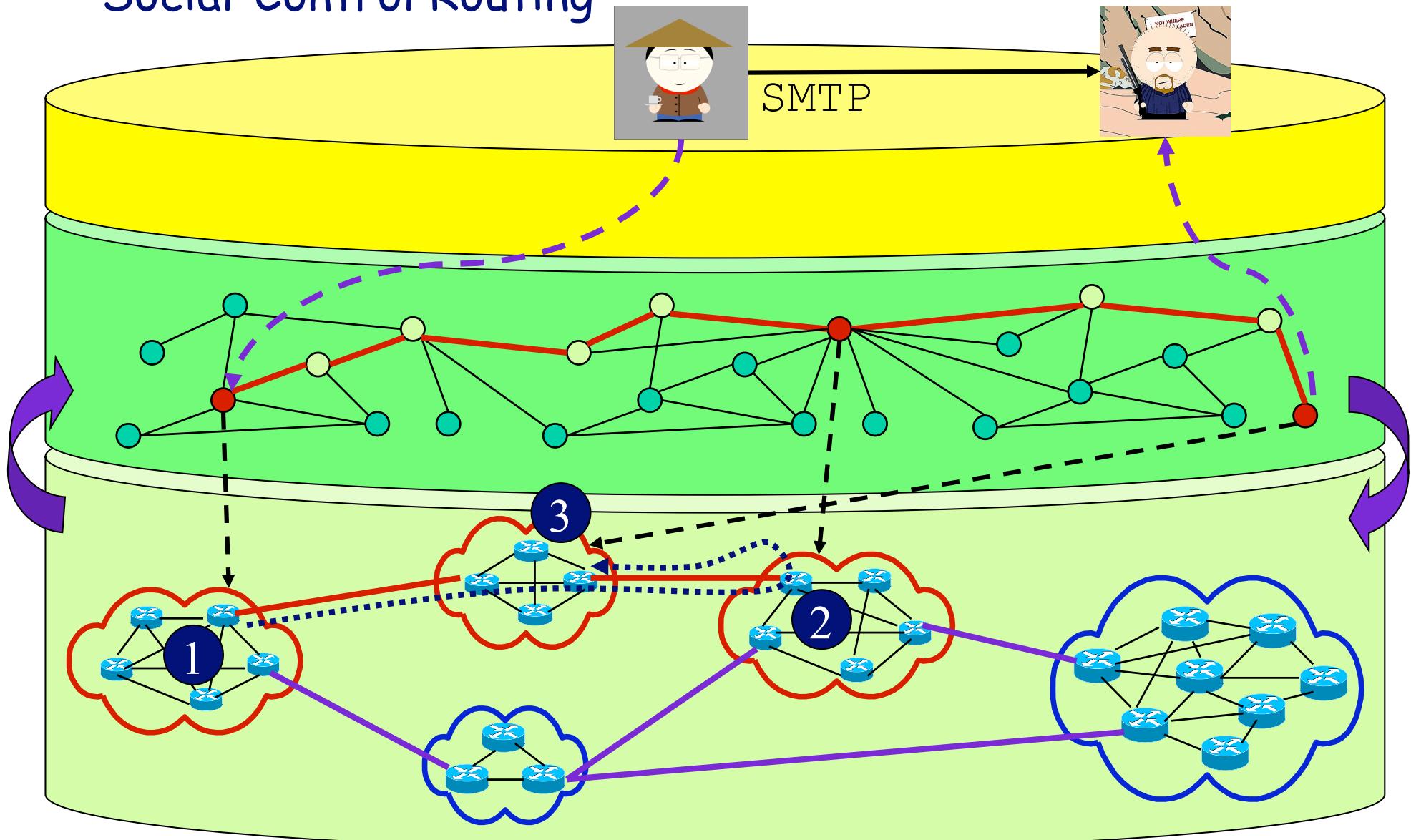




Social-Control Routing



Social-Control Routing



Facebook | S. Felix Wu

Getting Started Latest Headlines Deals on Canon Pow... .google http://www.d MapleStory - Global ... KenBrashear.com - K... http://www.d

SquirrelMail 1.4.8-4.0.1.el5.c... Gmail - Inbox (1061) - sfelixw... Programme: fireworks Facebook | S. Felix Wu

facebook Home Profile Friends Inbox 66 S. Felix Wu Settings Logout Search

S. Felix Wu

Wall Info Photos Boxes Six Degrees +

Update Status Share Link Add Photos Causes Add Video

What are you doing right now? Post

All Posts Posts by S. Felix Posts by Others Settings

Dec 6 S. Felix is now friends with Jonathan M. Smith. 2:57am - Comment

Dec 5 S. Felix commented on Chih-Chieh Lien's photo. 9:15pm
Congratulation! That is a very significant honor!

Advertise

Edge out thy neighbor.

The new H-D® XR1200™ motorcycle. Only 750 available for pre-order. Begins 12/1/08. Ends 12/15/08. Go to [-d.com/xr1200](#) for

Gets Real

Social Network has its potential value in communication!!

Add Comment - 1 Comment

S. Felix Wu at 7:27pm December 4
It is interesting that, after I reserved a hotel room, I was asked to consider to join this group of Hotel ME on Facebook. Now, Facebook is everywhere...

ROCCO GETS REAL

Transferring data from www.facebook.com...

Value of the “Social Network”

- While Social Network has its own unique value in facilitating human communication,
- A major concern about losing this “value”
 - while we are unsure about how to quantify the true value...

Your Street Credit:	3.0 / 5.0
Your Piggy Bank:	\$45
Total Spent:	\$0
Your Street Rep:	Rookie

Have a FightPoke *you'd* like to see here? [suggest it](#) now!

Type a friend's name to FightPoke:

AND Select a FightPoke to send ...

Poke message (optional):

[do it](#)



throw a happy cow at them



have Crazy Carrot jump on them



trash their heart



spam them to hell (and back)



scare them at bedtime



have Papa Smurf take them to task



have Cupid mess them up



have monkeys mock them

Fighter's Club

- A couple millions users
 - A Coalition game ~ like Warcraft
 - Team members who are Facebook friends receive higher fighting powers
-
- ~1400 new friendships established daily
 - ~10% of users with >95% friendships purely based on this game.

Friendship requested

 趙小四 (Taiwan)
You have no friends in common.
[Add to list...](#)

[Confirm](#) [Ignore](#) [Send Message](#)

 Zhao Ming (China)
You have no friends in common.
[Add to list...](#)

[Confirm](#) [Ignore](#) [Send Message](#)

 Calvin Loke (Malaysia)
You have no friends in common.
[Add to list...](#)

[Confirm](#) [Ignore](#) [Send Message](#)

 Narges Arastouie
You have no friends in common.
Narges found you using the Friend Finder.
[Add to list...](#)

[Confirm](#) [Ignore](#) [Send Message](#)

BTW, this guy stole 24 millions dollars from me during my DSL demo to Prof. George Kesides from Penn Stat!

Open Issues

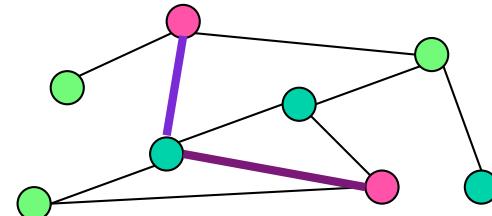
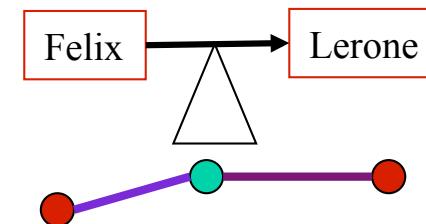
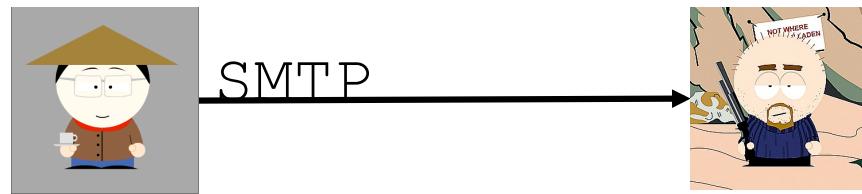
- What is the “**value**” of this social network?
- How would this “**value**” be distributed and allocated to each individual peers?
- MySpace, Facebook, LinkedIn didn’t define the “game” for **network formation** and **value allocation**.
 - But, it is important to design the game such that the OSN will eventually converge to a state to best support the communities.

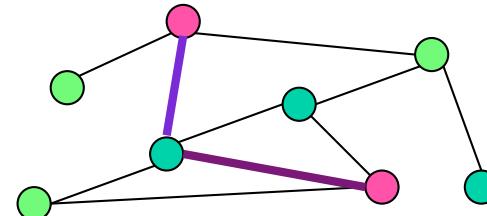
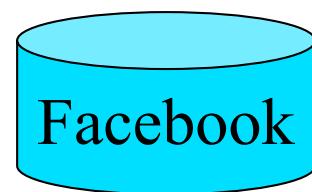
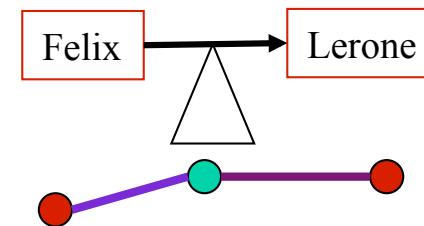
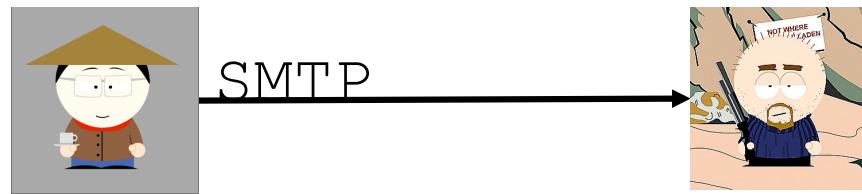
Value of OSN

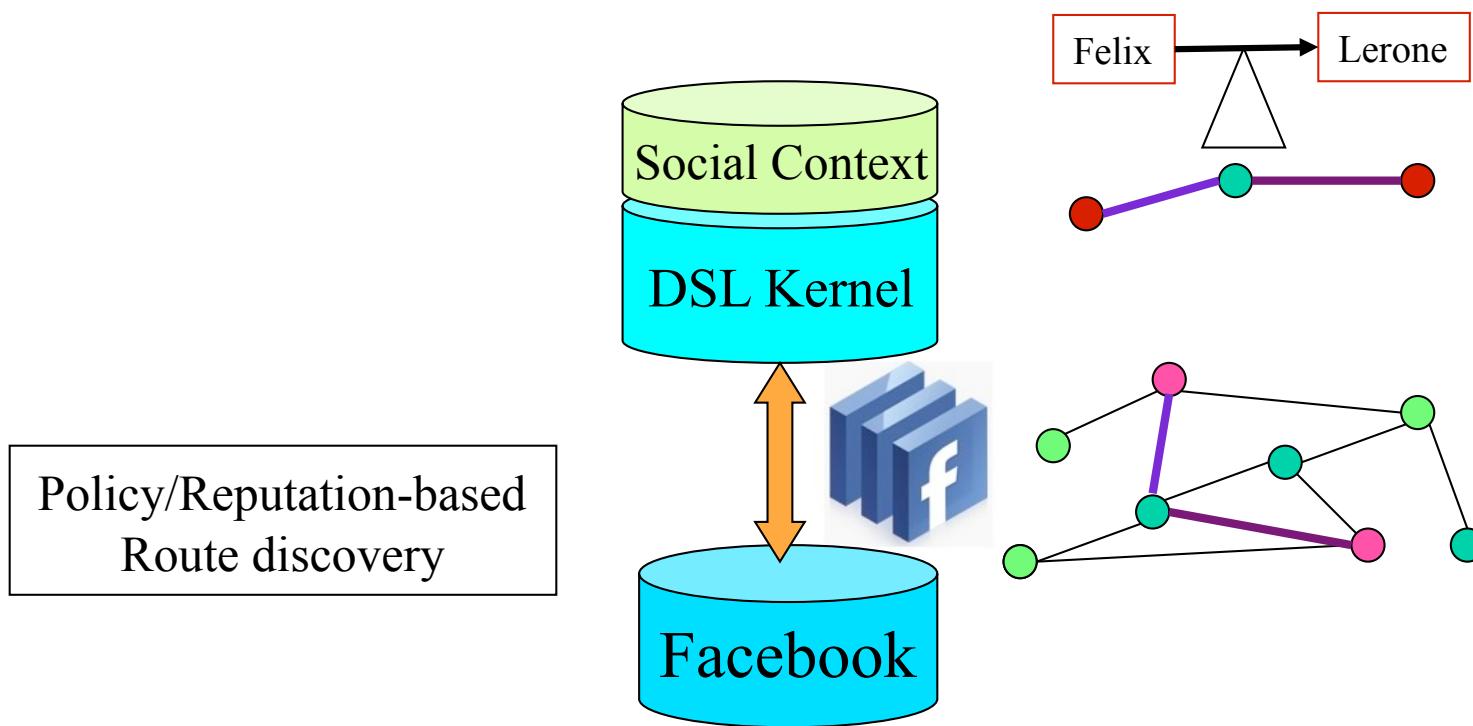
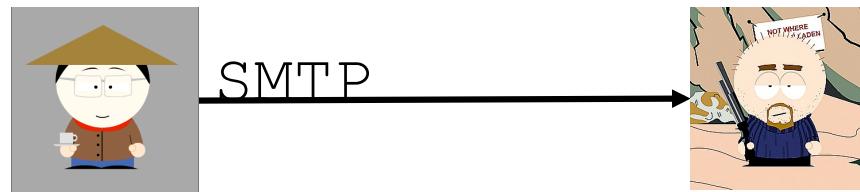
- How to leverage the value of Online Social Network in Communication?
- How to architect the Social Network itself such that its value can be protected?

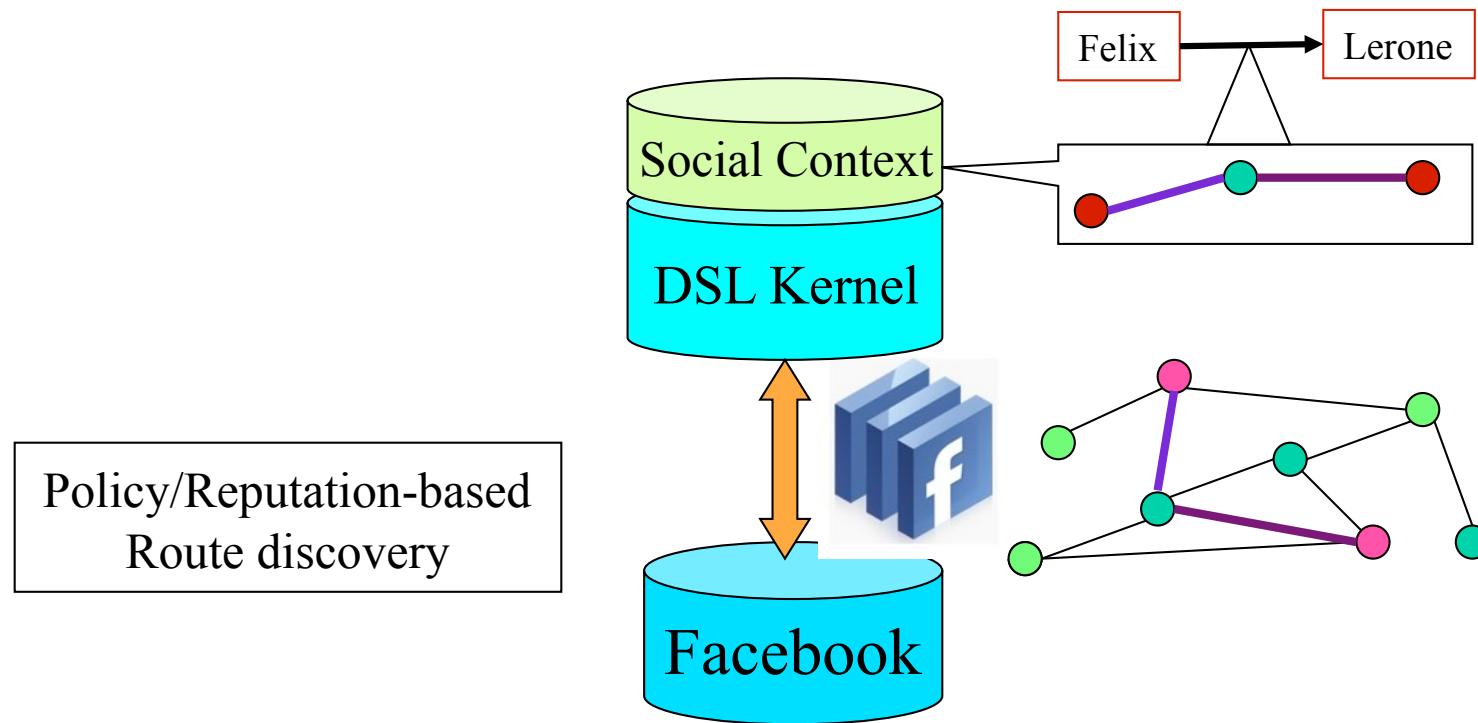
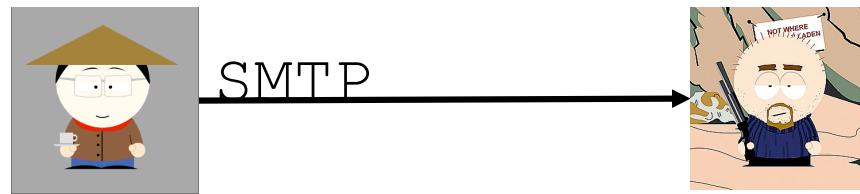
In this talk...

- We will focus on the centralized architecture based on Facebook as the social context provider.











CyrusDSL

Directory Status: Approved

Your application is currently listed in the Application Directory. You can [edit](#) or [delete](#) your entry.

Monthly Active Users

10

About Page Fans

7

Total Users

49

API Key

9becd41f69320e3b31fe19b717a378c9

Secret

ff931e790cb9d60df20ddba3f111bd77

Application ID

19142451122

Contact Email

wu@cs.ucdavis.edu

Support Email

wu@cs.ucdavis.edu

Callback URL

http://cyrus.cs.ucdavis.edu/ellominifb/pfDSL_02.py/callt



Home

Profile

Friends

Inbox 66

S. Felix Wu

[Advertise](#)

[Create Feed Template](#)

[DataStoreAdmin](#)

[Edit About Page](#)

[Home](#) | [View Users](#) | [View Friends](#) | [Invite Friends](#) | [My Keyword Manager](#) | [Received Keywords](#) | [Send Message](#) | [Received Messages](#) | [Sent Messages](#) | [Help](#)

[CyrusDSL](#)

[+ View tutorial](#)

CyrusDSL

Davis Social Links allows you to better connect with friends in the Facebook social network

At this point the application identifies friends that have the application, allows a user to set up his/her own keywords, and shows the social link path used to deliver a particular message.

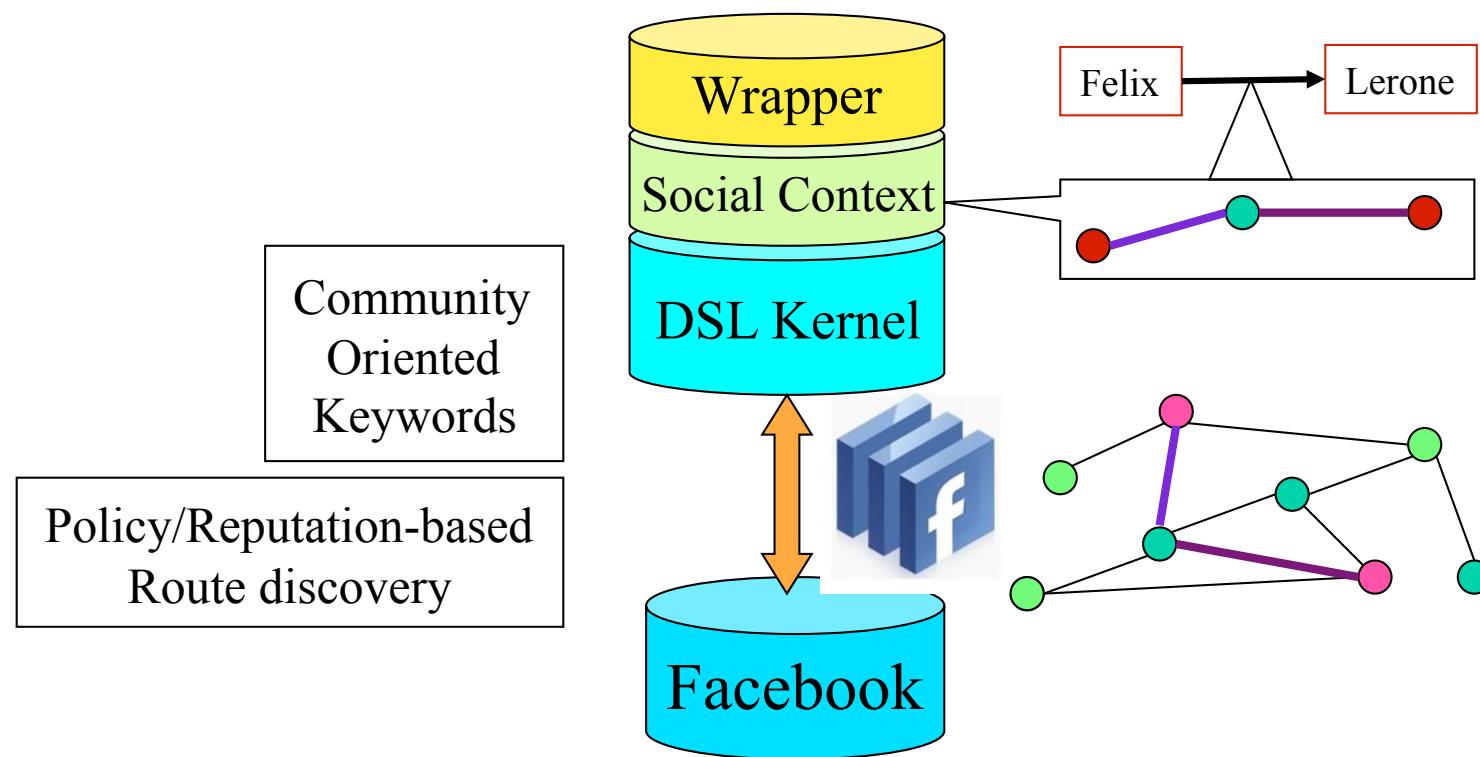
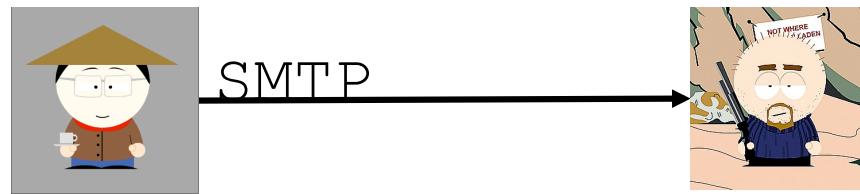
A tutorial for how to use DSL is available [here](#).

(you have to add this app before you will be able to write messages here)

[CyrusDSL Testimonials/Comments](#)

There are no posts.

[Write Something](#)

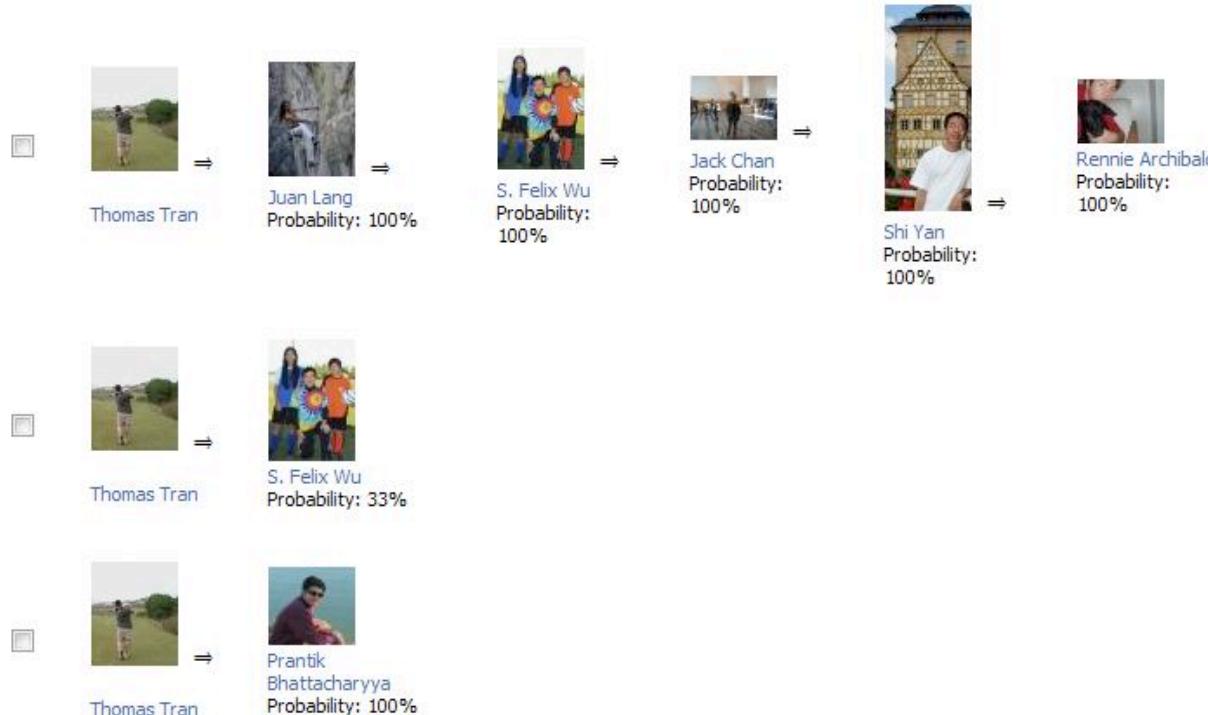


Possible Targets Found! Select Recipients!!

Keywords: 'ayso'

Subject: 'Hello!'

Path to Targets



Send Messages

No Path to Targets:



Tyler Martin



Apoorv Kishore



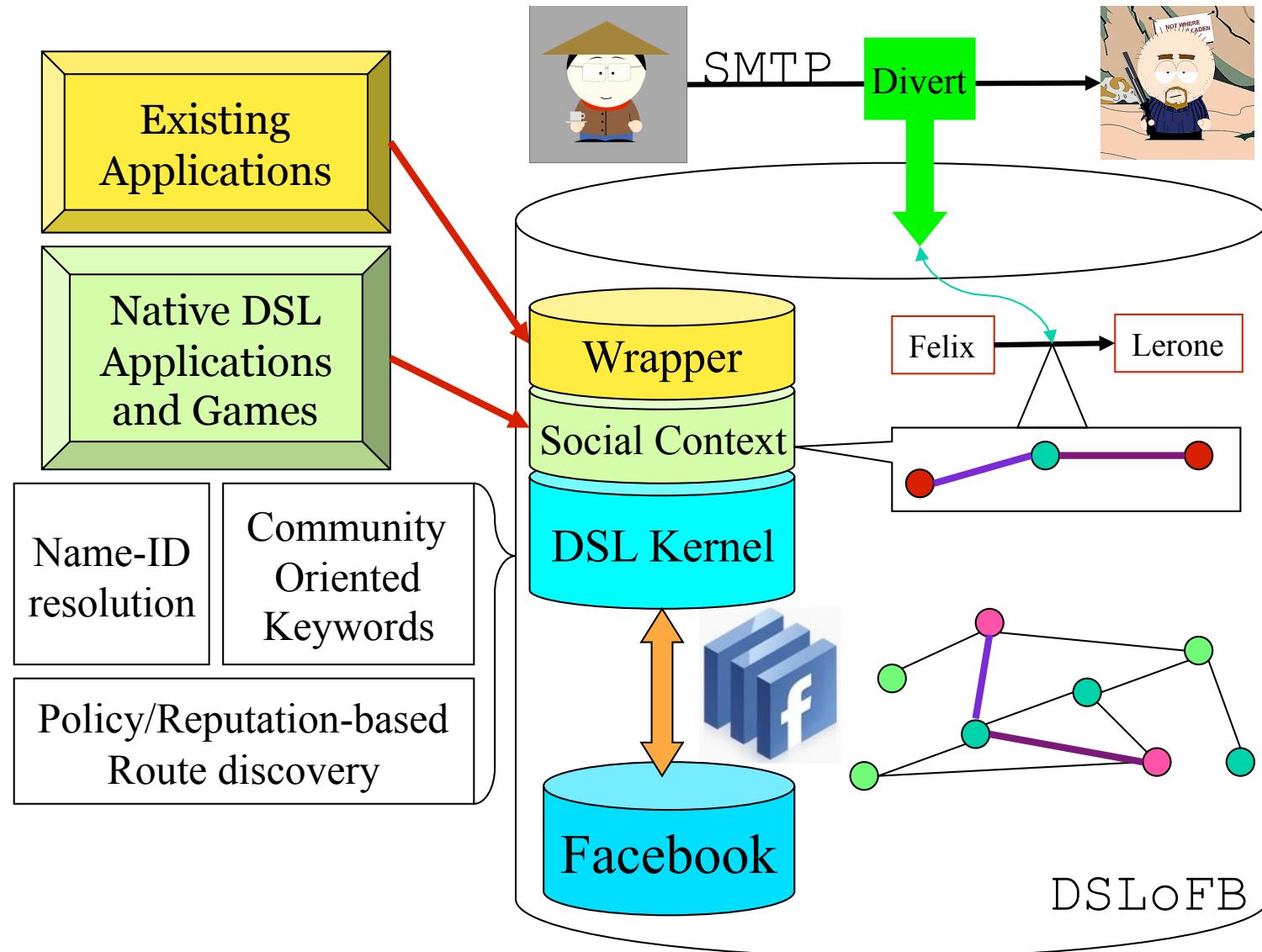
Yugandhar Muppala

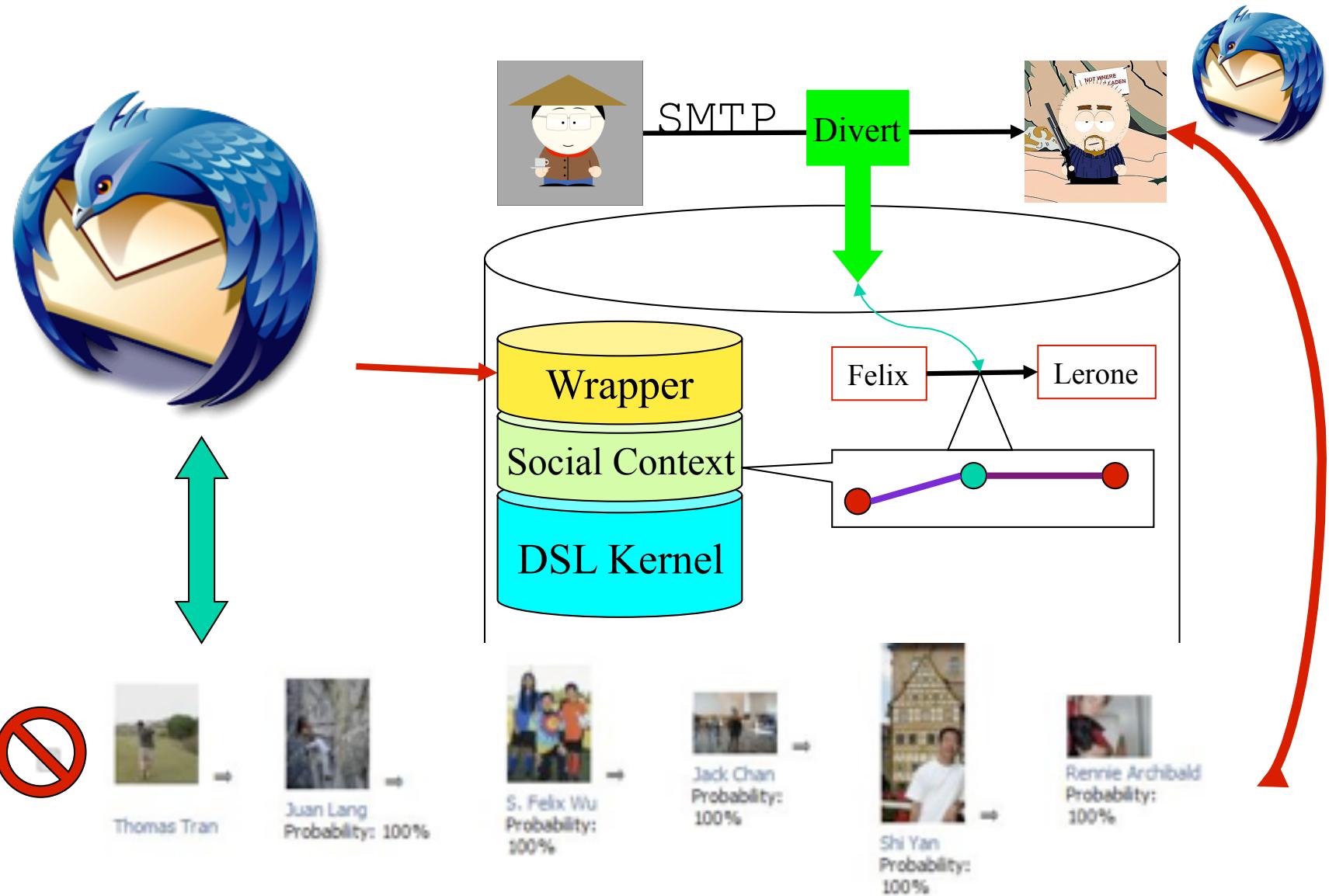


Xiaoliang Zhao



David Edelstein





A couple issues ...

- How to establish the social route?
 - How would "A" know about "D" (or "**D's identity**")?
- How to maintain this "**reputation network**"?
 - KarmaNet: A Feed-back Trust Control System

Who is Salma?



Name:

Salma Enan

Networks:

Temple Grad Student '10

UC Davis Alum '06

Philadelphia, PA

Friends:

1 mutual friend

[Add as Friend](#)

[Send a Message](#)

[View Friends](#)

Hello



From:
[Salma Enan](#)



Via Friend:
[Lerone Banks](#)
Using Keys: ['soccer']
Date: Fri Apr 18 16:36:50 2008

Hi Dr. Wu, I am Lerone's girlfriend, Salma. He told me that you are interested in soccer. I am too and I am from the Davis community but I no longer live there. Even though we are not friends on Facebook and have never met, its nice to be able to send you a message through Lerone. You can try to send me a message with the keyword 'philadelphia, pa' (without quotes but must have space before 'pa'). take care, Salma

[Home](#) | [Invite Friends](#) | [My Keyword Manager](#) | [Send Message](#)

Davis Social Links

Send A message

Keyword List: Subject:

Message:

Dear **Salma** and **Lerone**,

I am Beijing and working on my slides for DSL.
I need an example, so I will use the only key word I
know to contact others.

Thanks and have a good week in California.

-Felix
p.s., And, make sure that **Lerone** takes the right
medicine.

Fractional Real Estate



Learn more about luxury fractional residences in the San Francisco Bay Area. Download the free expert guide.

[More Ads](#) | [Advertise](#)

The Social Path(s)

facebook

Profile edit Friends | ▾ Inbox | ▾

home account privacy logo

Search

Applications edit

- Photos
- Groups
- Events
- Marketplace
- Developer
- Instant Messaging
- Causes

+ more

Get an iPod Shuffle



Page built by Davis Social Links

Your Message has been sent!!!

Keywords: 'philadelphia, pa'

Subject: 'from Felix Wu in Beijing'

Paths to targets

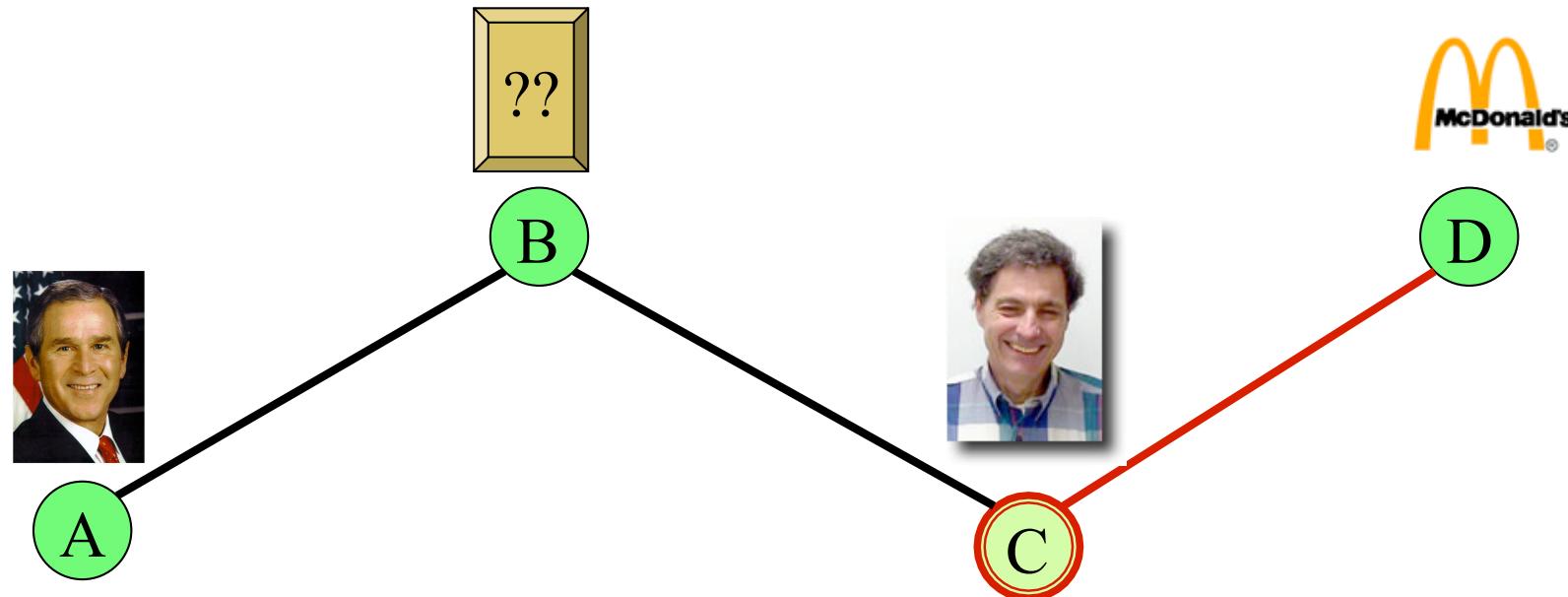
S. Felix Wu Matt Spear Lerone Banks Salma Enan

About Find Friends Advertisers Developers Terms Privacy

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58

Finding



A2D, while D is McDonald's!

D would like “customers” to find the right route.

“idea: keyword propagation” e.g., “McDonald’s”

Facebook | CyrusDSL

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Done

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http://apps.facebook.com/cyrusdsl/setupkeywords

CyrusDSL + View tutorial

My Keyword Manager

Attribute	Depth	Community Keywords
ayso	5	uc davis
fellowship	5	dccc
ids	5	seclab
soccer	5	ayso
uc davis	5	uc davis

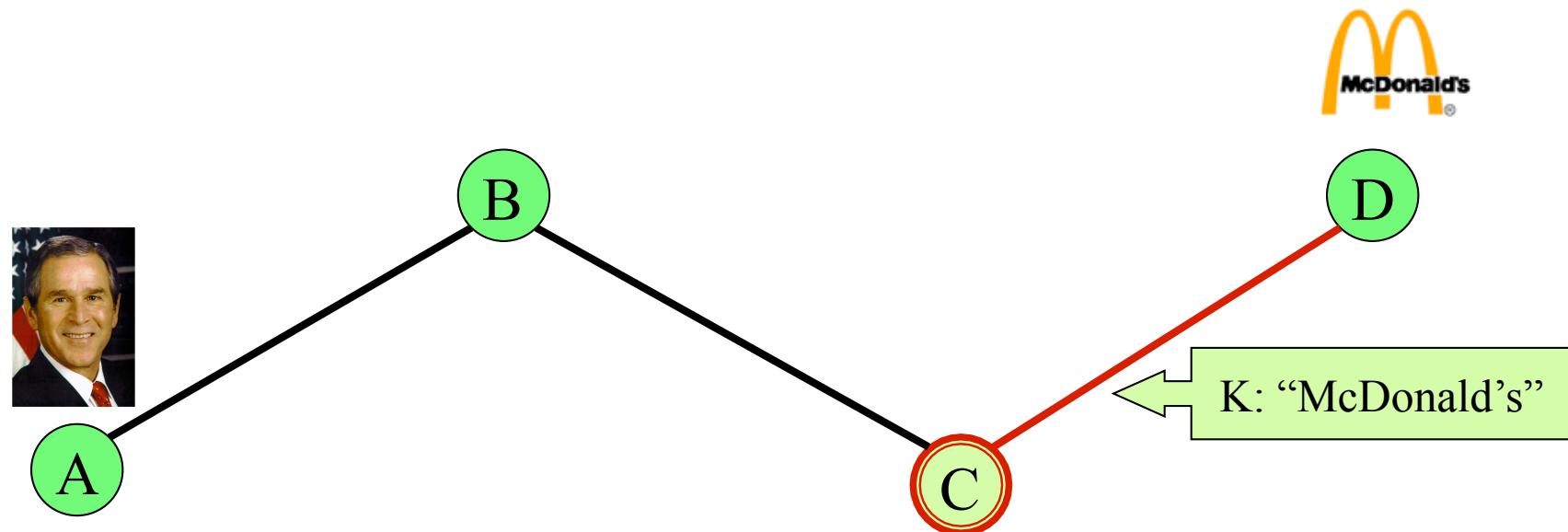
Add New

Done

Online Friends (2)

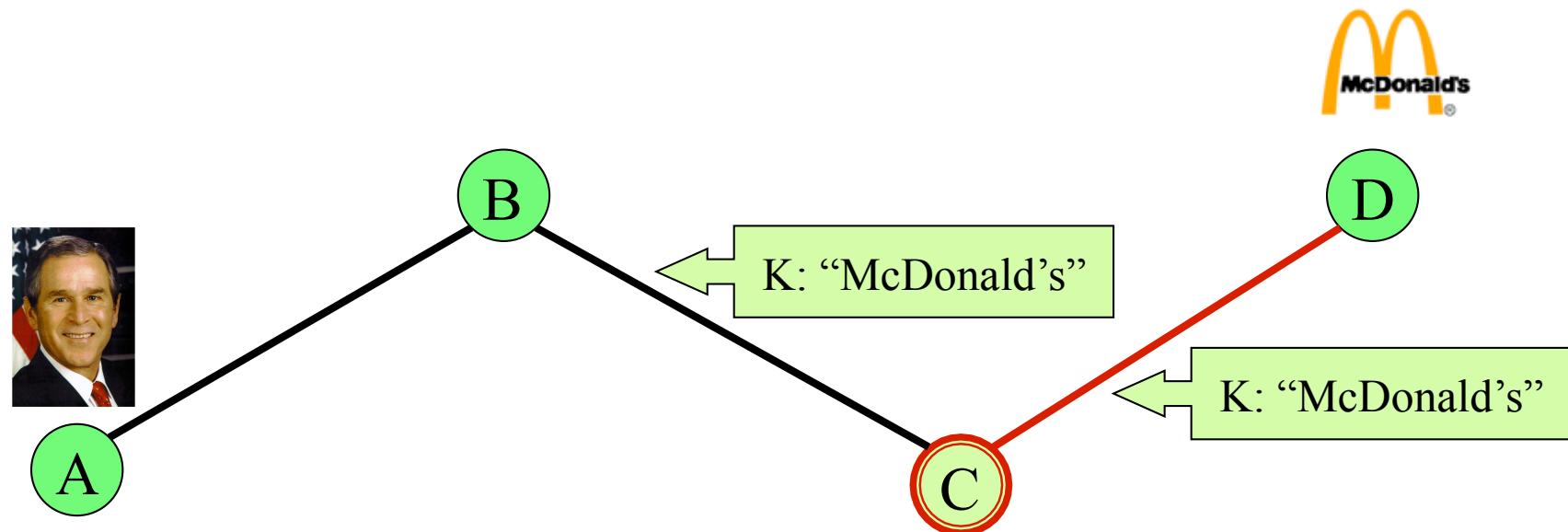
40

Announcing



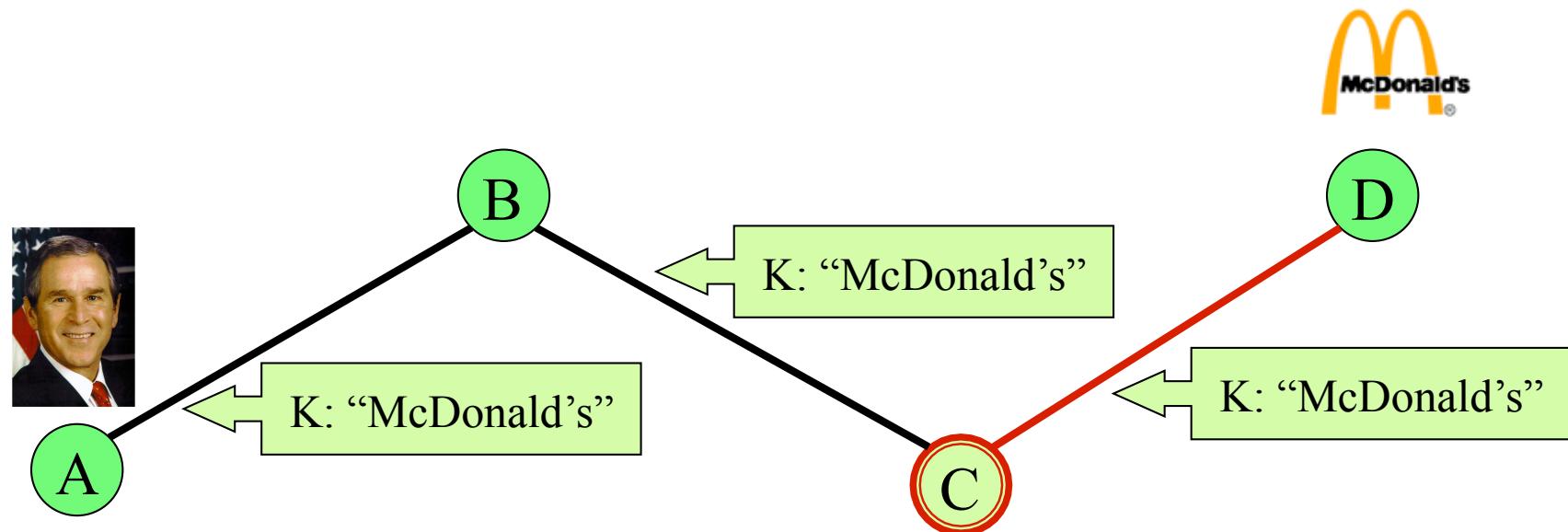
Hop-by-hop keyword propagation

Announcing



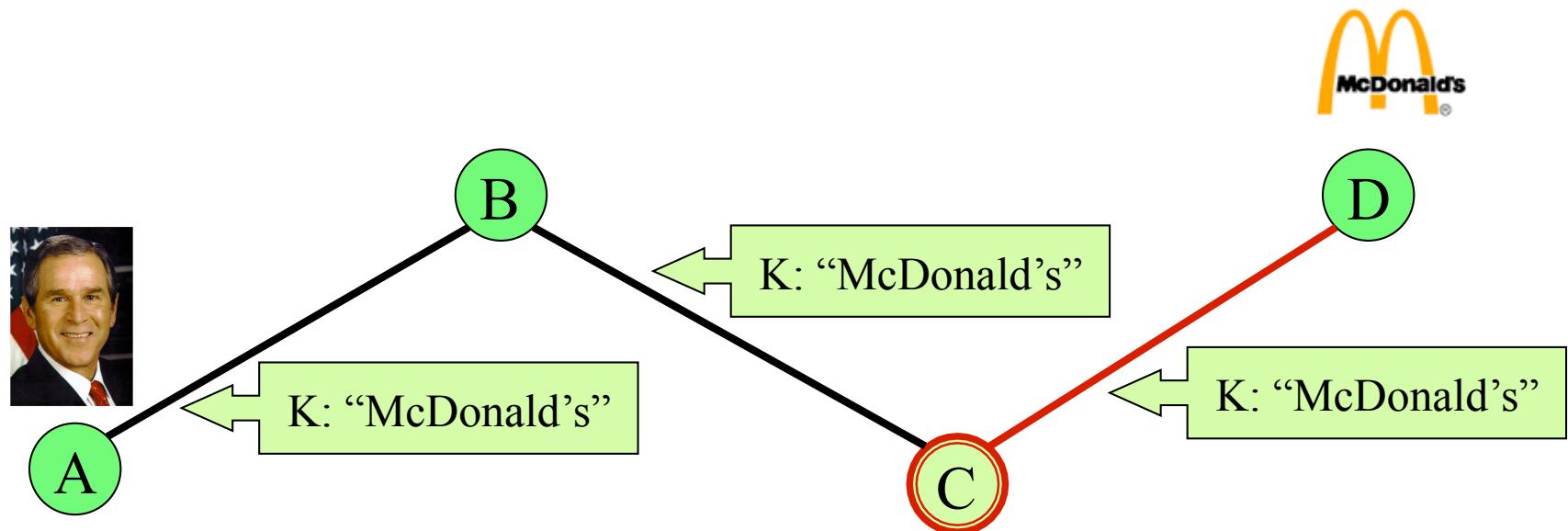
Hop-by-hop keyword propagation

Announcing



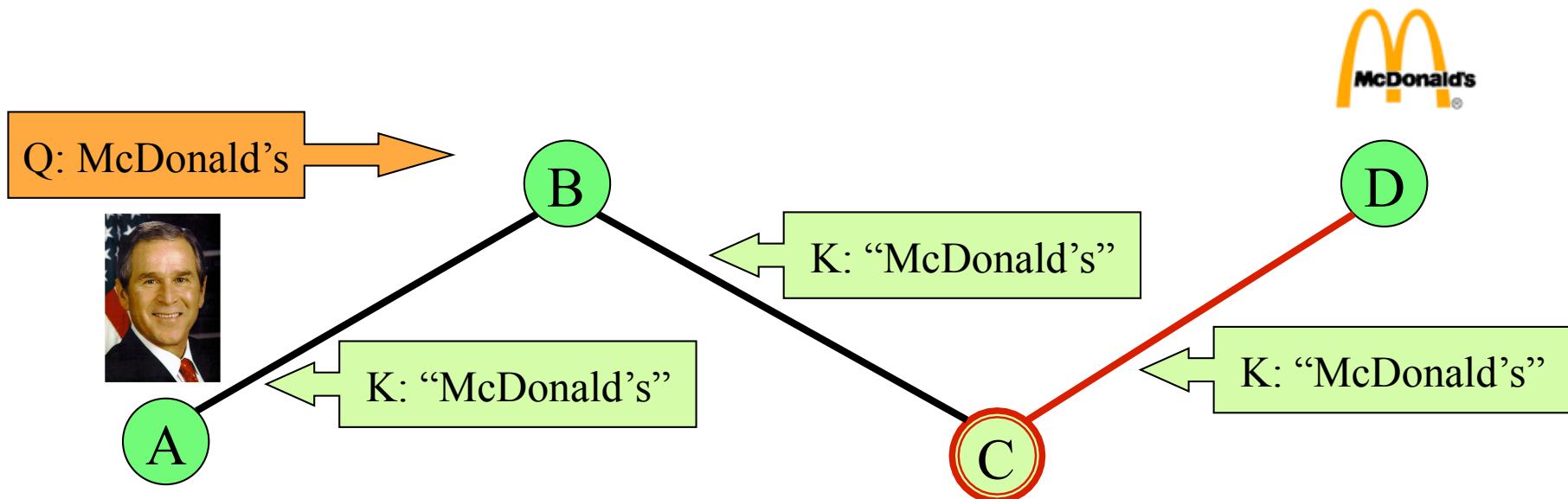
Hop-by-hop keyword propagation

Announcing



Hop-by-hop keyword propagation
And, I know I am doing FLOODING!!

Now Finding



Search Keyword: “McDonald’s”

A might know D's keyword via two channels

(1) Somebody else (2) From its friends

Questions: does D need an identity? Scalable?

Application Tests

- Example 1: credential-oriented
 - “PKI certificate” as the keyword
 - If you can sign or decrypt the message, you are the ONE!
- Example 2: service-oriented
 - Service/protocol/bandwidth support
- Example 3: offer-oriented
 - Please send me your coupons/promotions!

"Routable Identity"

- Application identity $=M=>$ Network identity
- Network identity $=R=>$ Network identity
- Network identity $=M=>$ Application identity

"App/Route Identity"

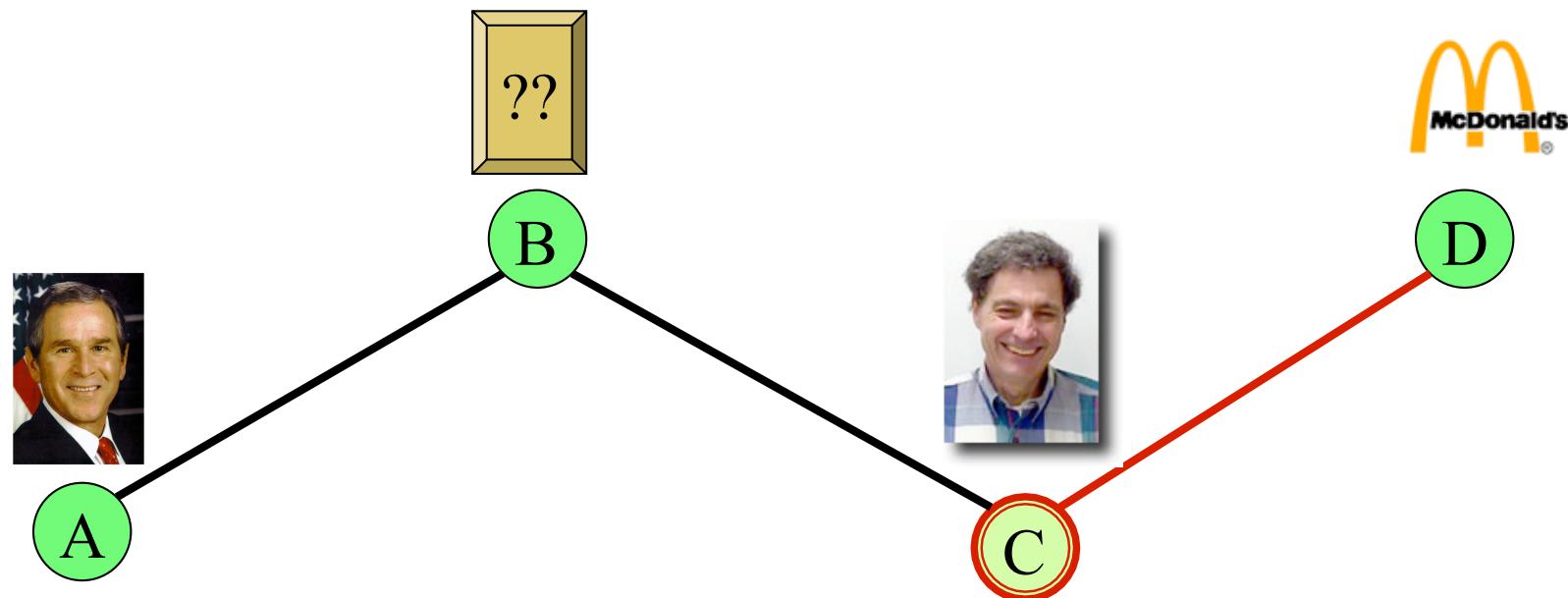
- Application identity $=M=>$ Network identity
 - Network identity $=R=>$ Network identity
 - Network identity $=M=>$ Application identity
-
- **Keywords =*(MF-R)*=> "Multiple Paths"**
 - Application identity selection
 - Network route selection

Scalability - Avoid the Flooding

- As it is, every keyword will need to be propagated to all the nodes/links (but the same keyword will be propagated through the same link once possibly with different policies).
- The issue: “who should receive my keywords?”



in Community of Davis

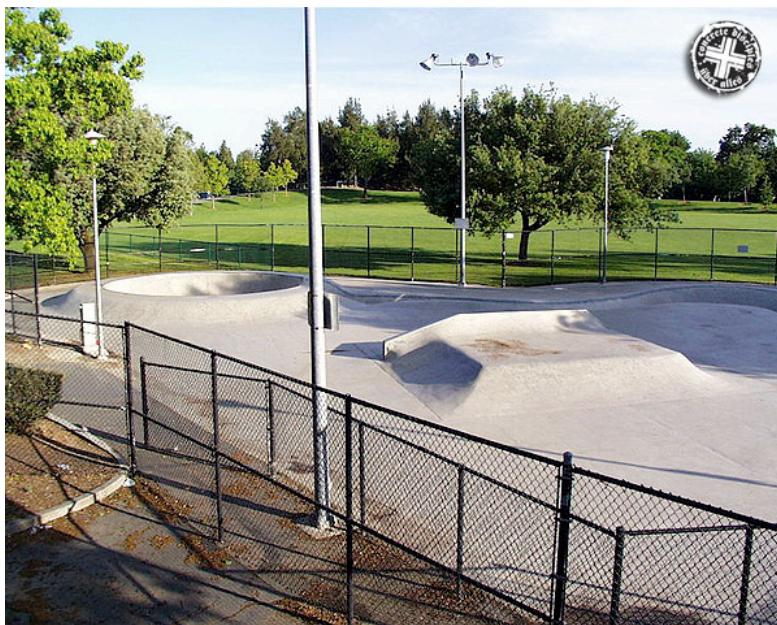


**Who should receive the keyword announcement for
“McDonald’s”?**



as the Social Peer

- Attributes:
 - {McDonald's Express, 640 W Covell Blvd, # D, Davis, (530) 756-8886, Davis Senior High School, Community Park, North Davis}



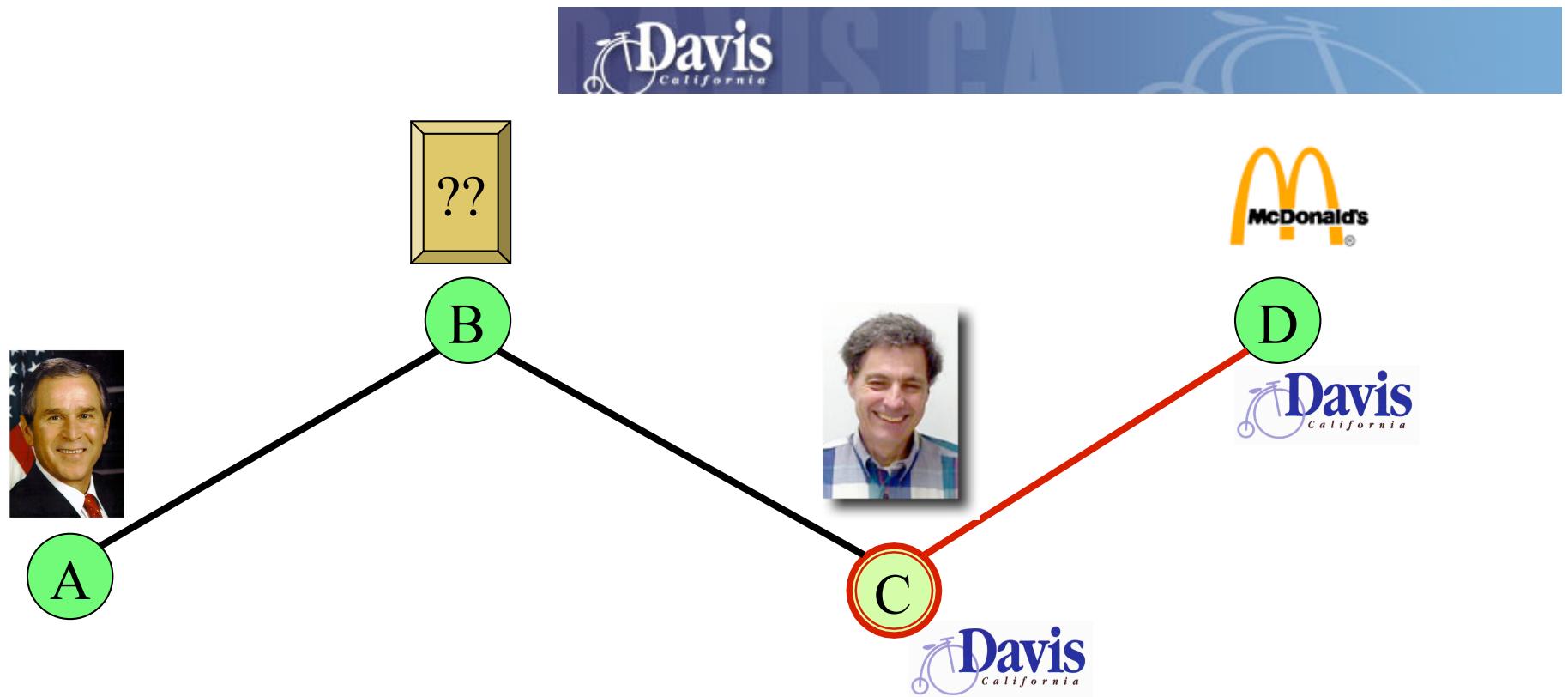
"Per-Keyword Policy"

- For each keyword, we will associate it with a propagation policy: $[T, N, A]$
 - T : Trust Value Threshold
 - N : Hop counts left to propagate (-1 each step)
 - A : Community Attributes
- Examples:
 - $[>0.66, 4, "Davis"]$ K via L_1
 - $[>=0, \infty, \emptyset]$ K via L_2

Scalability & Controllability

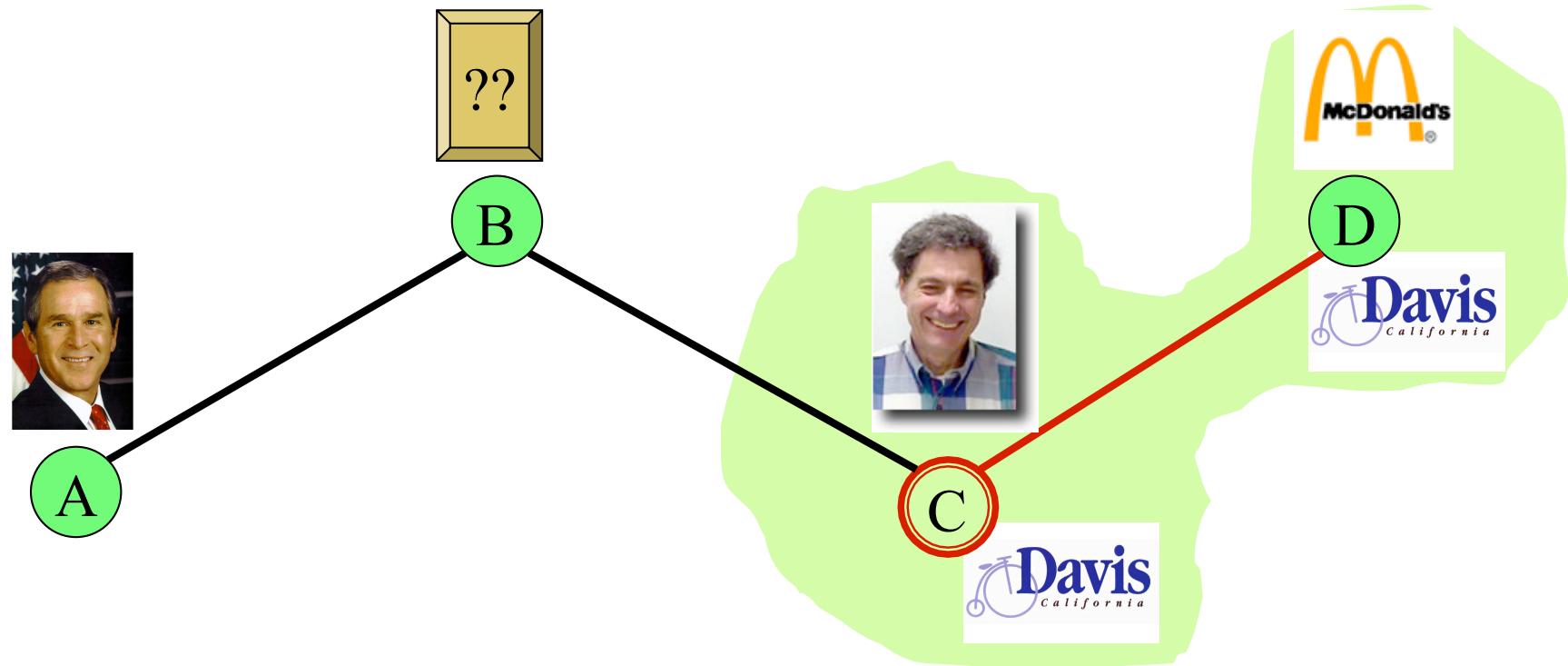
- McDonald's doesn't want to flood the whole network
 - It only wants to multicast to the "Target set" of customers
- And, it only wants this target set of users being able to use that particular keyword to contact.
 - Receiver/owner controllability

Social/Community Attributes



Who should receive the keyword announcement for
“McDonald’s”? Answer:  Davis

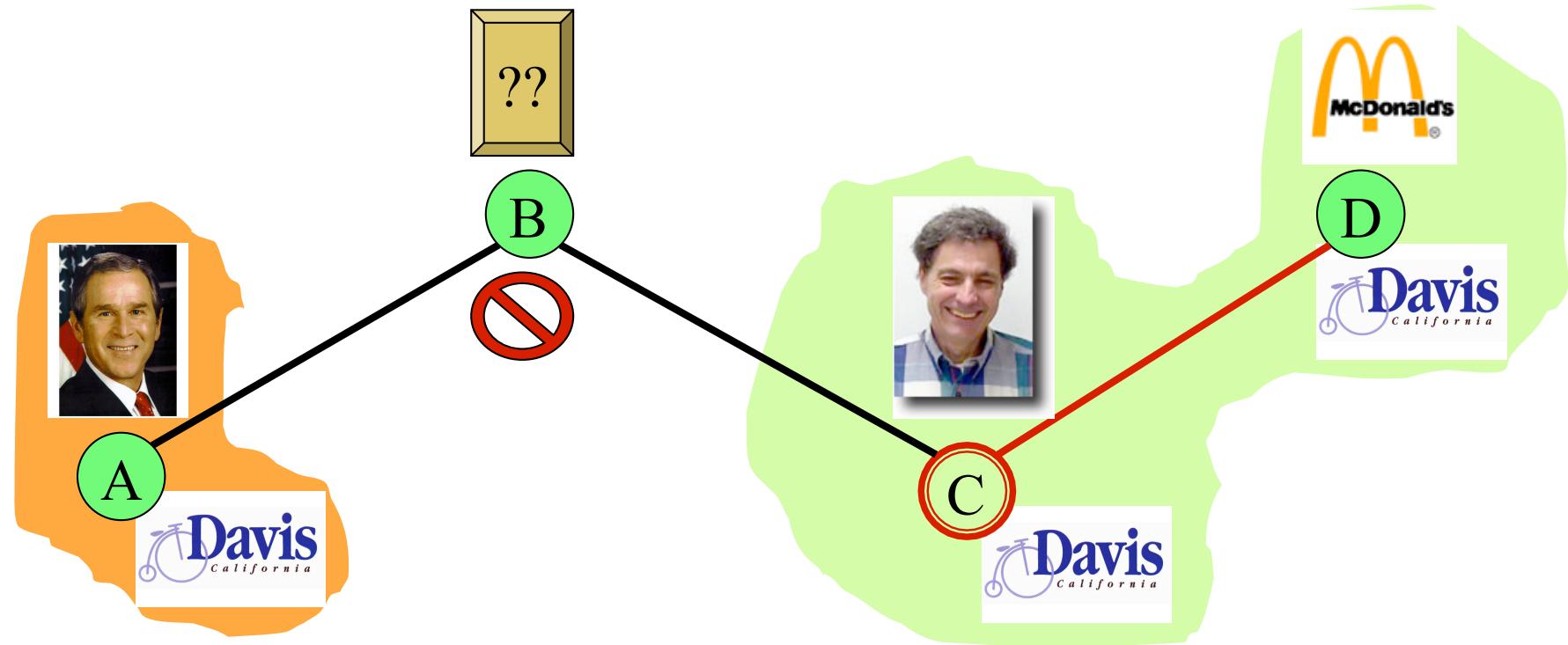
Davis California Community



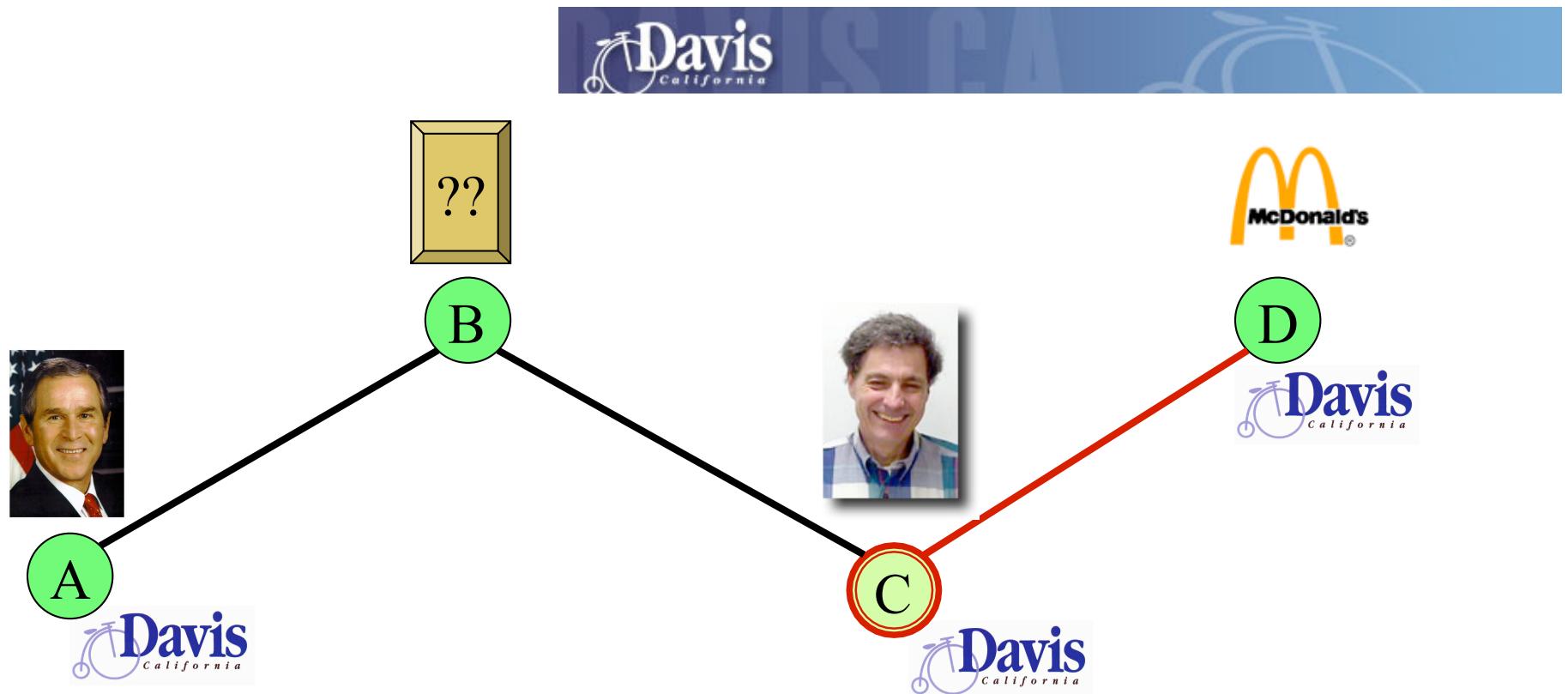
Community

- A **connected** graph of social nodes sharing a set of community attributes

Davis California Community

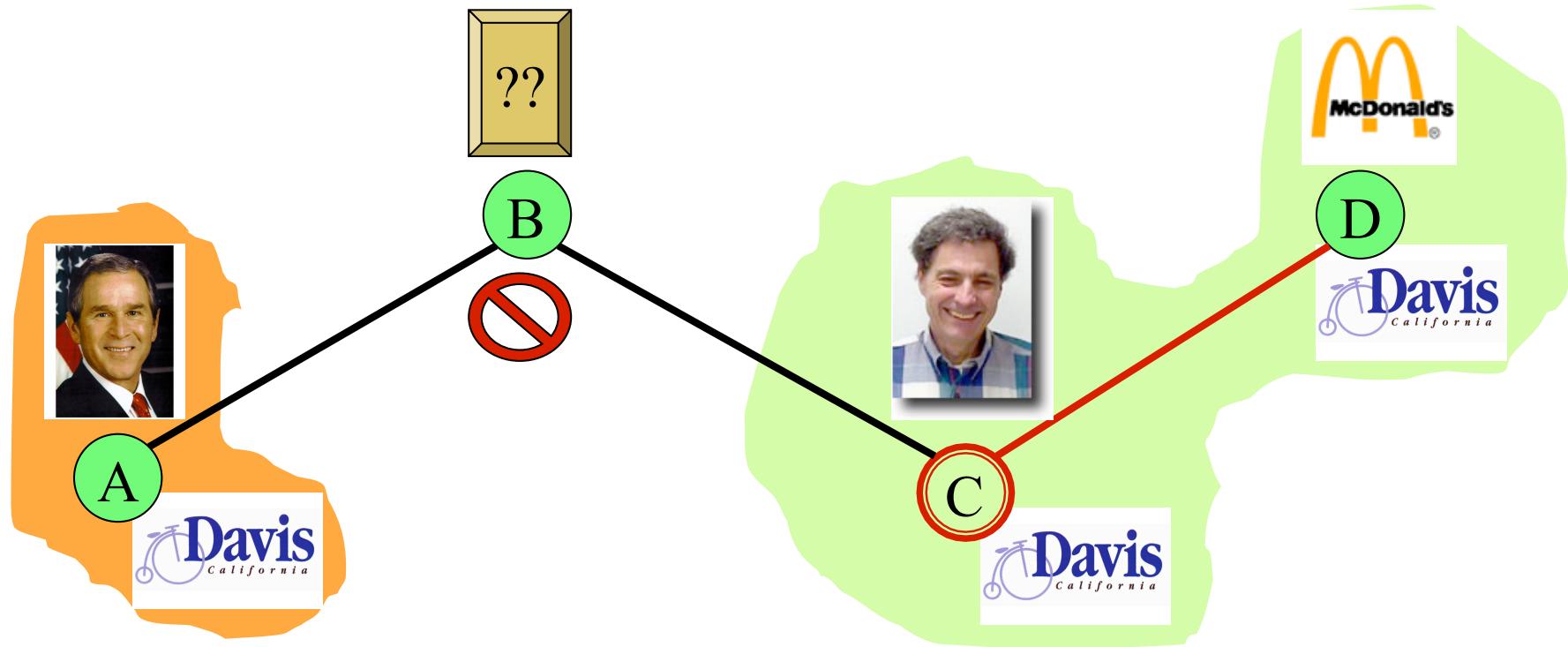


Social/Community Attributes



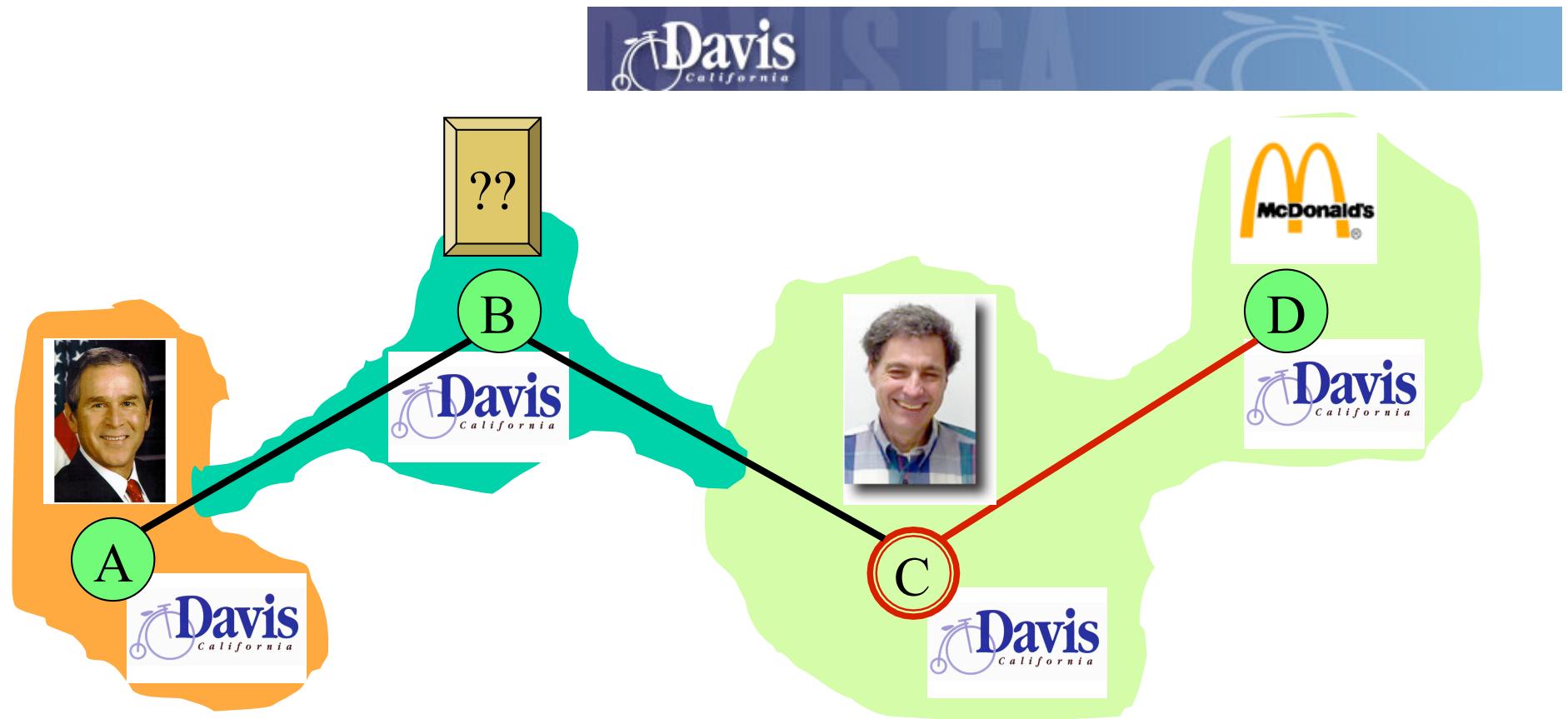
**Who should receive the keyword announcement for
“McDonald’s”? Answer: *Davis* but not ALL**

Davis California Community



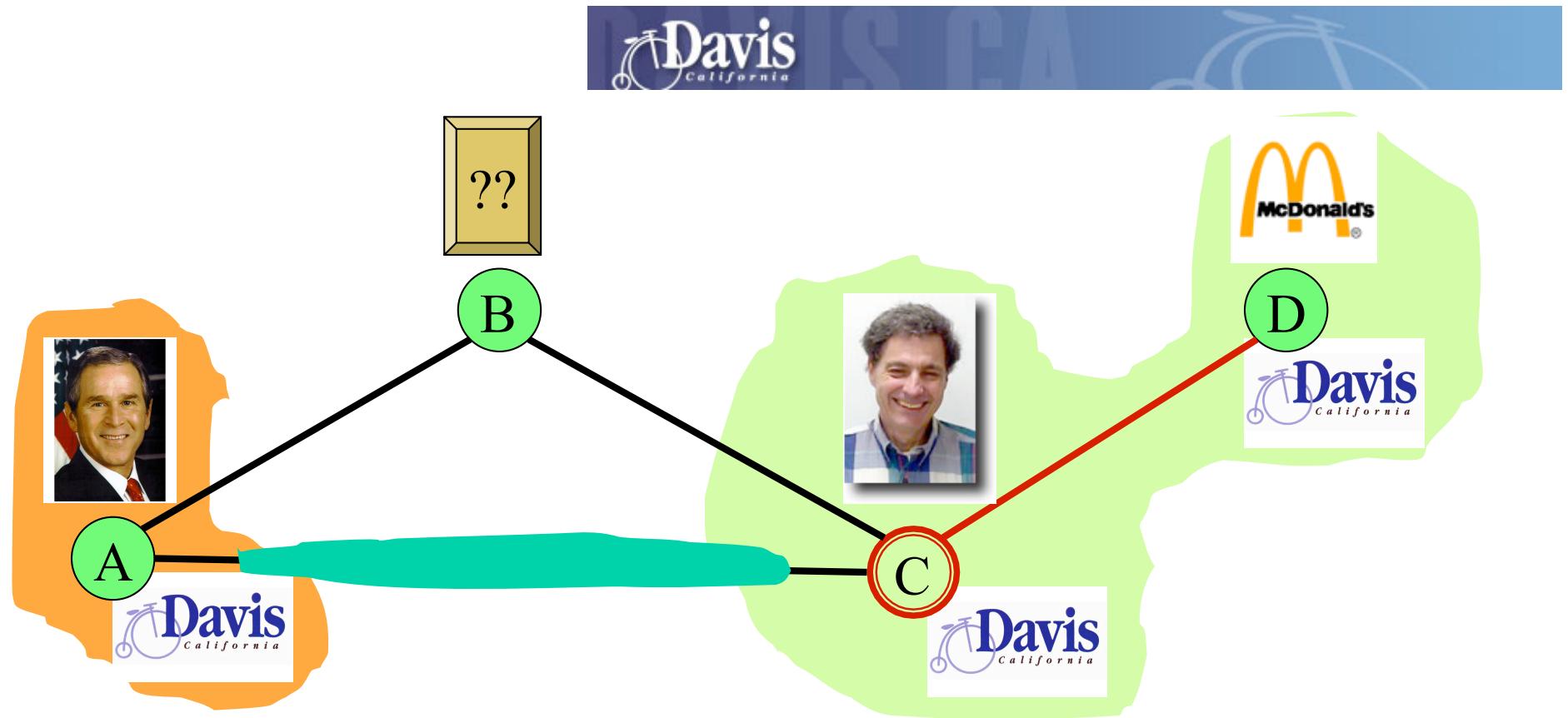


Network Formation





Network Formation



Both A & C: why would A & C be willing to establish a direct friendship?

http

facebook.

Roughly your
friends (or
friend²s)

Anybody with an IP address

http

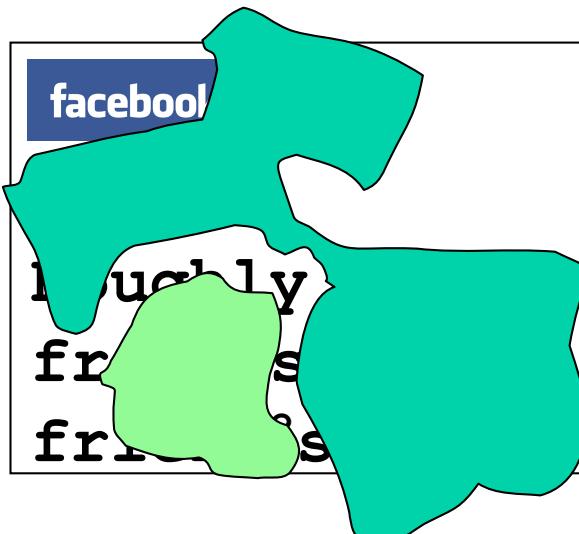


Roughly your
friends (or
friend²s)

Quality of the Friendship may
have been out of control...

Anybody with an IP address

http



Anybody with an IP address

"Per-Keyword Policy"

- For each keyword, we will associate it with a propagation policy: $[T, N, A]$
 - T : Trust Value Threshold
 - N : Hop counts left to propagate (-1 each step)
 - A : Community Attributes
- Examples:
 - $[>0.66, 4, "Davis"]$ K via L_1
 - $[>=0, \infty, \emptyset]$ K via L_2

One Route path from A to D



End2End Trust: “is this really from A?”

RoutePath Trust: “Should this path be used?”

Basic Assumption about the Link

Pkt [a>d]



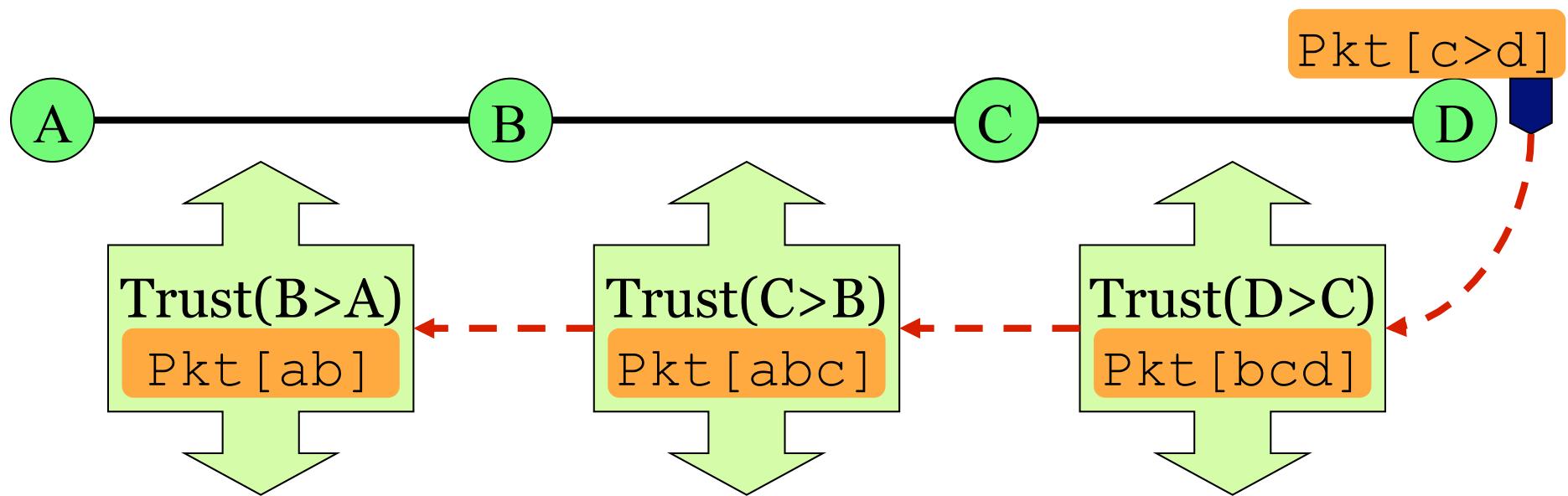
B & C have a way to decide whether they should establish a link between them, and they can authenticate each other:

- Secure MAC authentication
- Social Links in OSN
- Reputation-based Authentication
- Sybil Attack robustness

The Attack Model

- Does the receiver really like this packet being delivered to me **over a route path of links:**
 - Corrupted information
 - Spam
 - An incorrectly E2E-Authenticated packet
 - Malware
- Assumption: the receiver has its own security policy to determine whether it like the packet/message or not!

D decides, and rewards/punishes...



Beholder

Definition 3.13 (non-exploitability). A non-exploitable reputation function is a reputation function where: For any given world W , *for any vertex* v_i and any trust threshold h chosen by that vertex, no **untrusted** collusion in W can change the trust value of any agent v_j , *i.e.* $f(v_i, v_j)$. This is done by comparing trust values in two worlds: the standard honest world W and *any* world manipulated by an untrusted collusion.

Theorem 4.1. *All non-exploitable consensus-based reputation functions are trivial.*

Theorem 4.2. *There are non-trivial non-exploitable personalized reputation functions.*

Trust Structure

We define u 's trust values of v with respect to action a formally as:

$$T_a(u, v) = [m, n], \text{ where } a \in \mathbf{A} = \{A_{fwd}, A_{init}, A_{rt}\}$$

The probability of the next interaction will be good is defined as:

$$\sigma([m, n]) = \frac{m + 1}{m + n + 2} \in (0, 1) \quad (1)$$

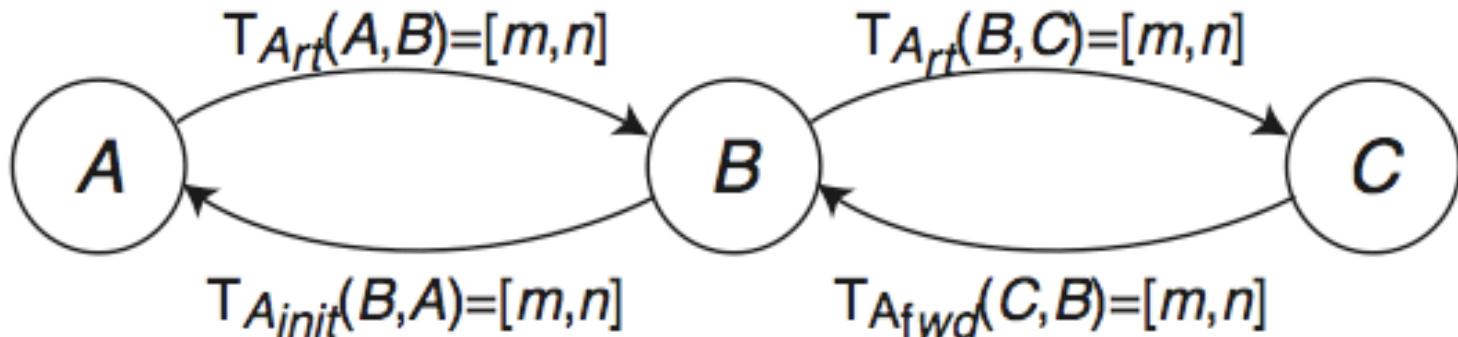
We want to stabilize these decentralized values such that they can be used to effectively choose the “best” route.

Three Trust Values per Relationship

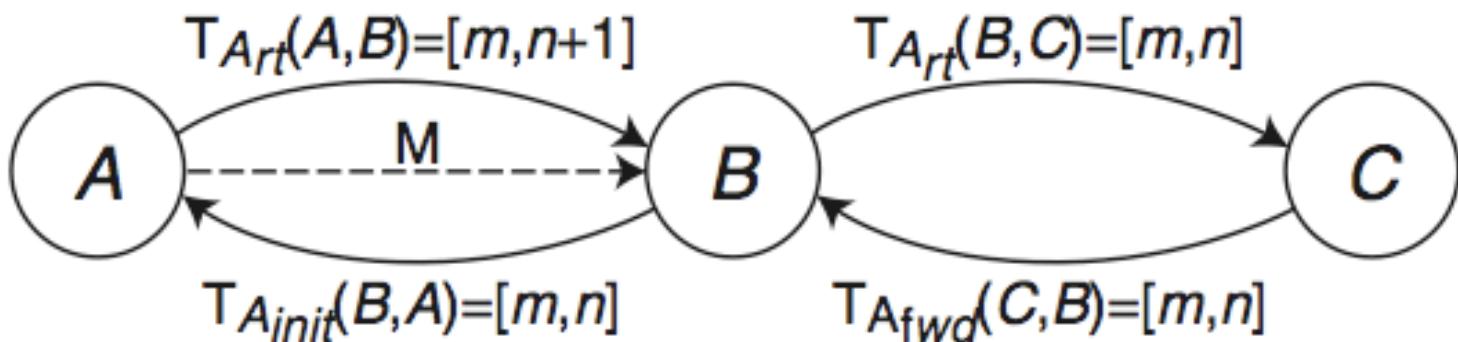


- $T_a(u,v)$: u is directly connected to v . How much u trusts v ?
- A_{init} : v , as the initiator, sends a packet to u .
- A_{fwd} : v forwards a packet to u . I.e., v is not the initiator of the packet.
- A_{rt} : sends a packet to, and, v forwards that packet to one of its other neighbors. And, the packet eventually reaches the destination.

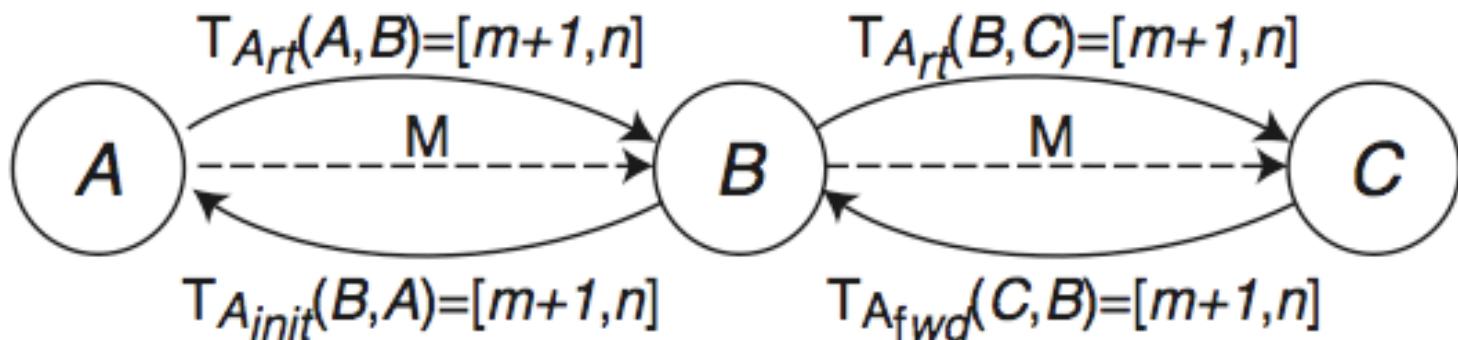
Example



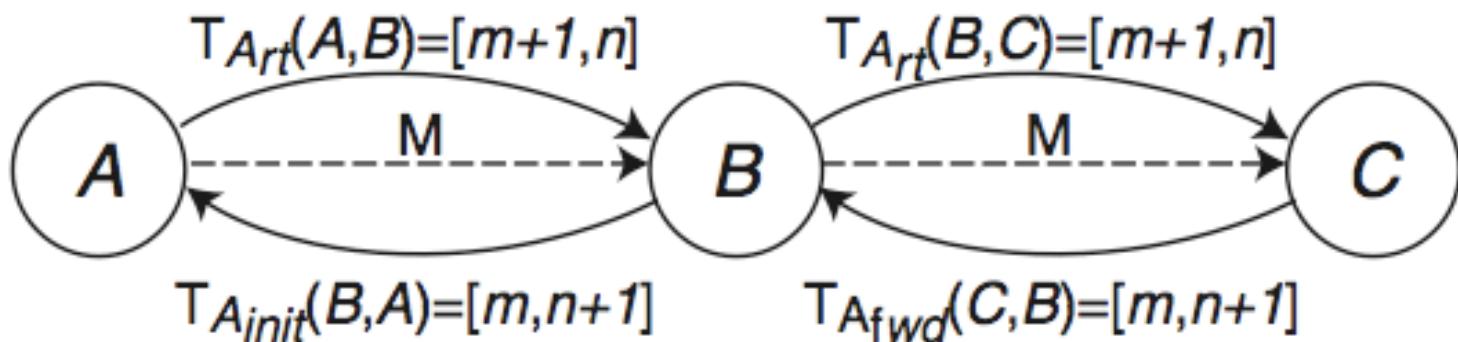
(a) Initial route, initializing, forwarding trust values.



(b) B drops A 's message: A waits for outcome until timeout, and punishes B 's A_{rt} .



- (c) C marks M as ham: The *outcome* = $[1, 0]$ will be propagated from C to A . A rewards B and B rewards C 's A_{rt} . C rewards B 's A_{fwd} and B rewards A 's A_{init} .



- (d) C marks M as spam: The *outcome* = $[0, 1]$ will be propagated from C to A . A rewards B and B rewards C 's A_{rt} . C punishes B 's A_{fwd} and B rewards A 's A_{init} .

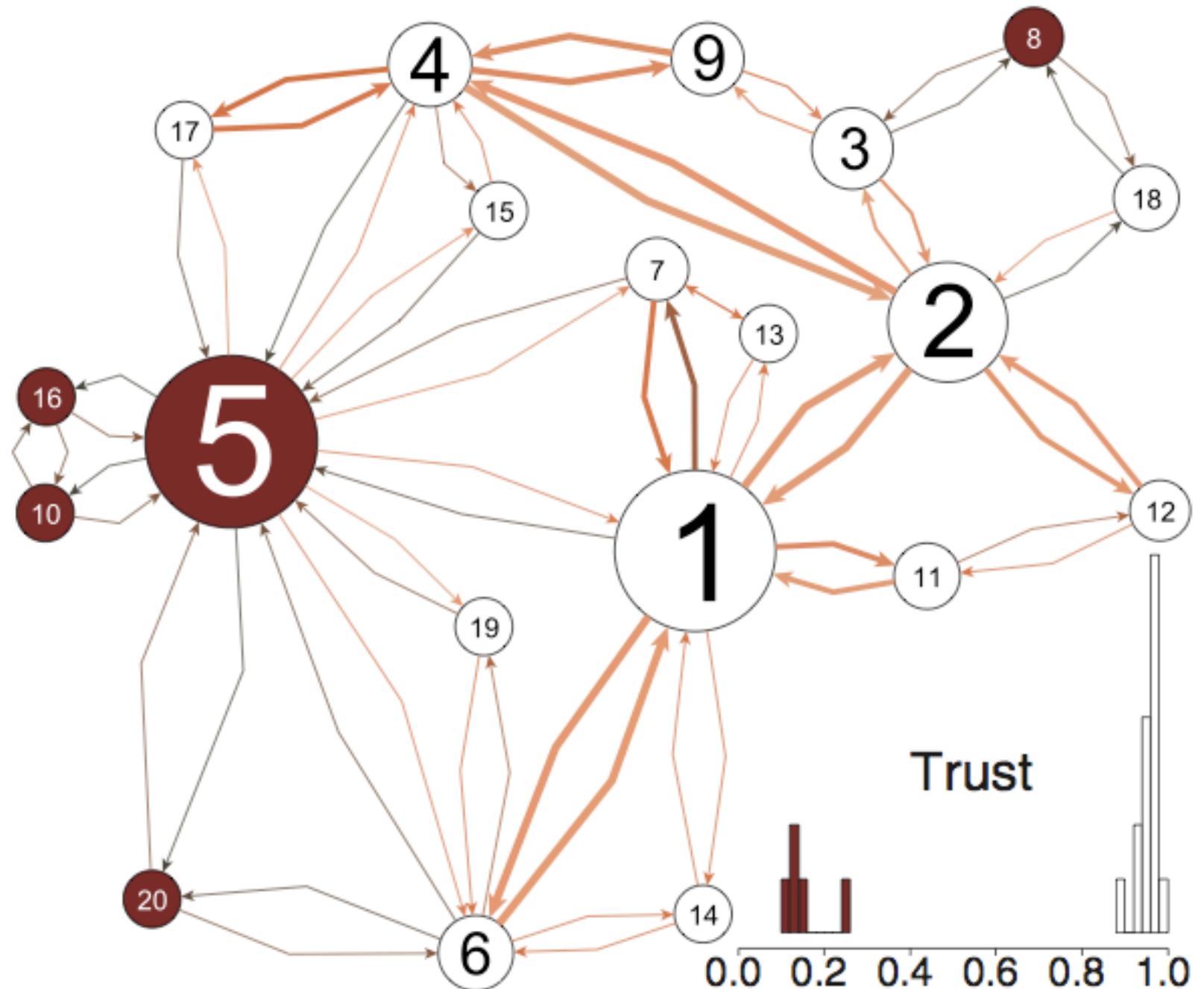
Routing with Trust

Algorithm 1 CHOOSEBESTNEIGHBOR(M)

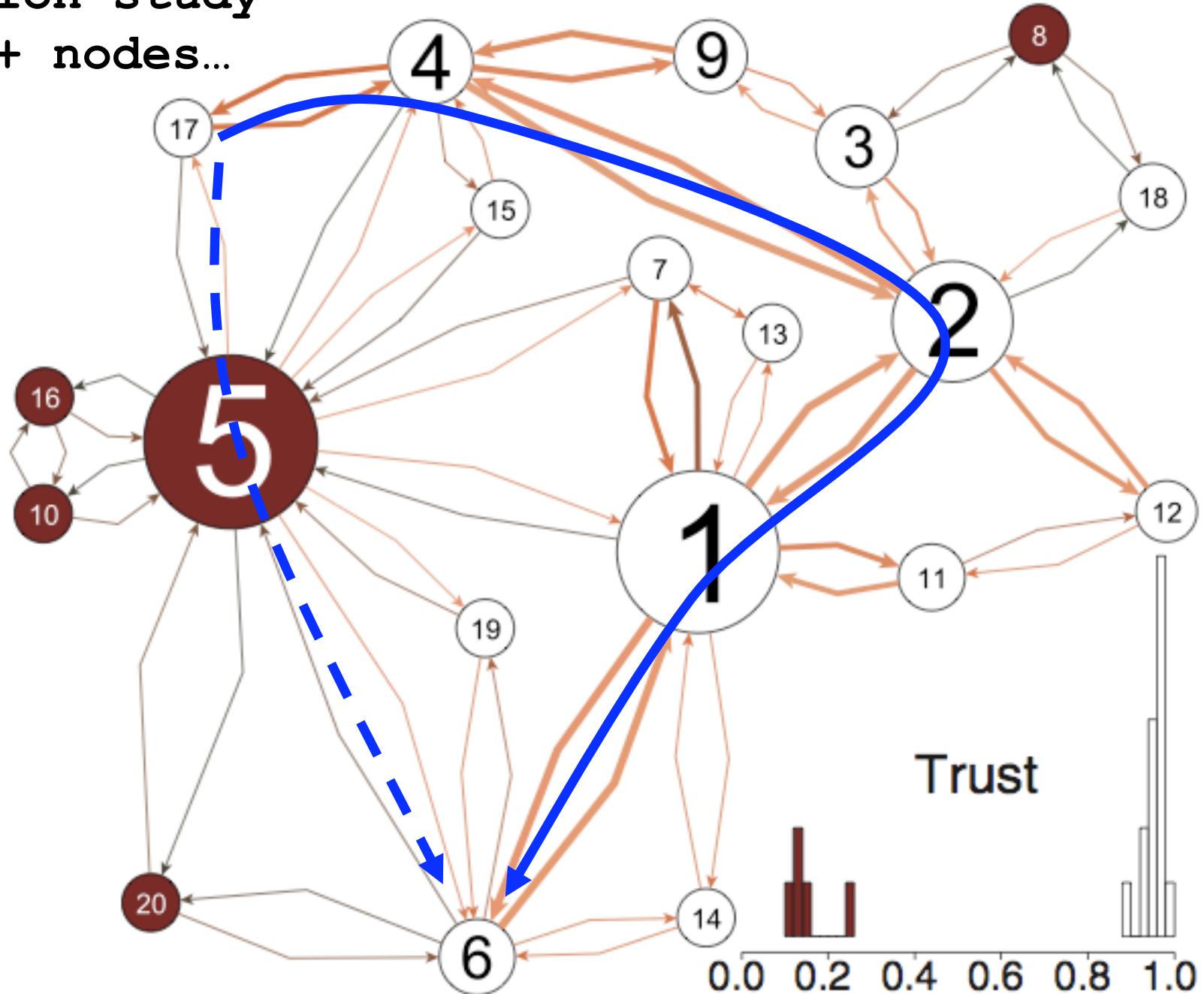
- 1: $\mathbf{T} \leftarrow \{\min_{a \in \mathbf{A}} T_a(u, v) | v \in \mathcal{N}(u)\}$
 - 2: $\mathbf{V} \leftarrow \{v | v \in \mathcal{N}(u) \wedge \text{NOTSEEN}(M, v) \wedge v = Dst\}$
 - 3: **Return** $\max_{v \in \mathbf{V}} (\frac{\alpha}{1 + \delta(v, Dst)} + (1 - \alpha) \cdot T[v])$
-

Algorithm 2 PROBABILITYOFDROPPING(M)

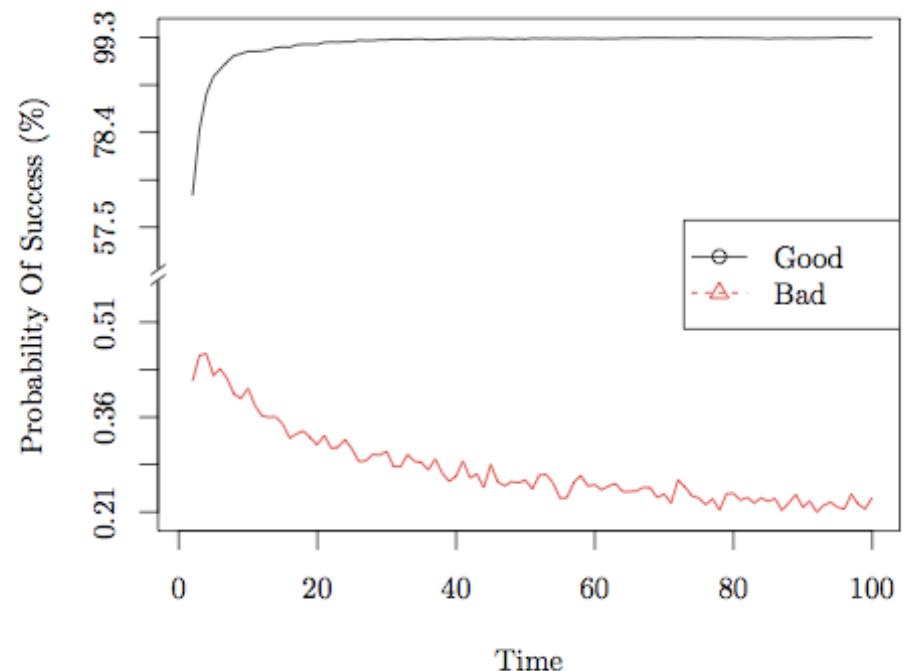
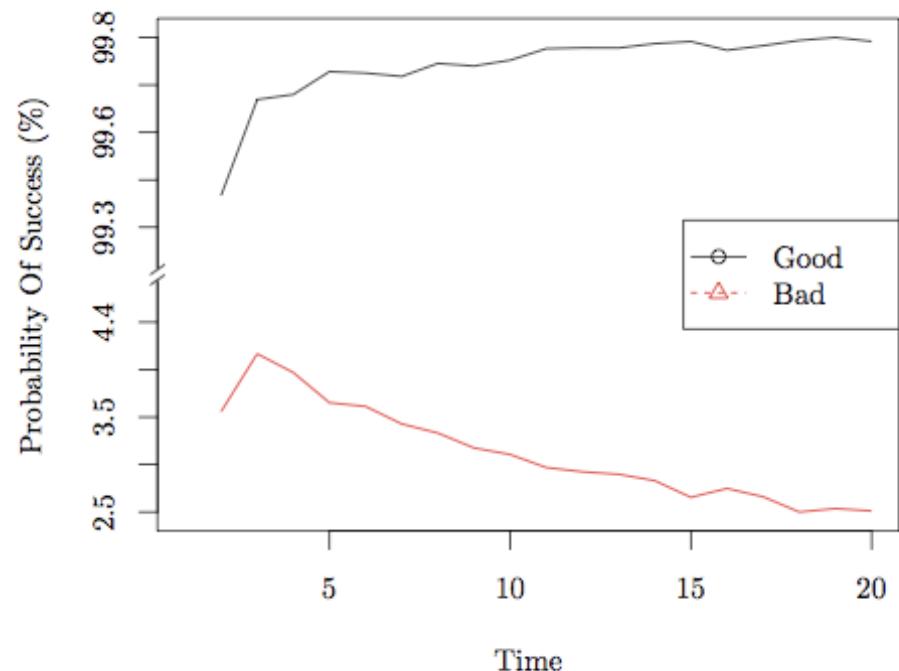
- 1: **If** PREVHOP(M) is initiator **Then** $\mathbf{A}' \leftarrow \{A_{init}, A_{rt}\}$
 - 2: **Else** $\mathbf{A}' \leftarrow \{A_{fwd}, A_{rt}\}$
 - 3: $T_{from} \leftarrow \{\min_{a \in \mathbf{A}'} T_a(u, from)\}$
 - 4: **If** $T_{from} > \tau$ **Then Return** 0
 - 5: **Else Return** RANDOM(0, 1) $> T_{from} ? 1 : 0$
-



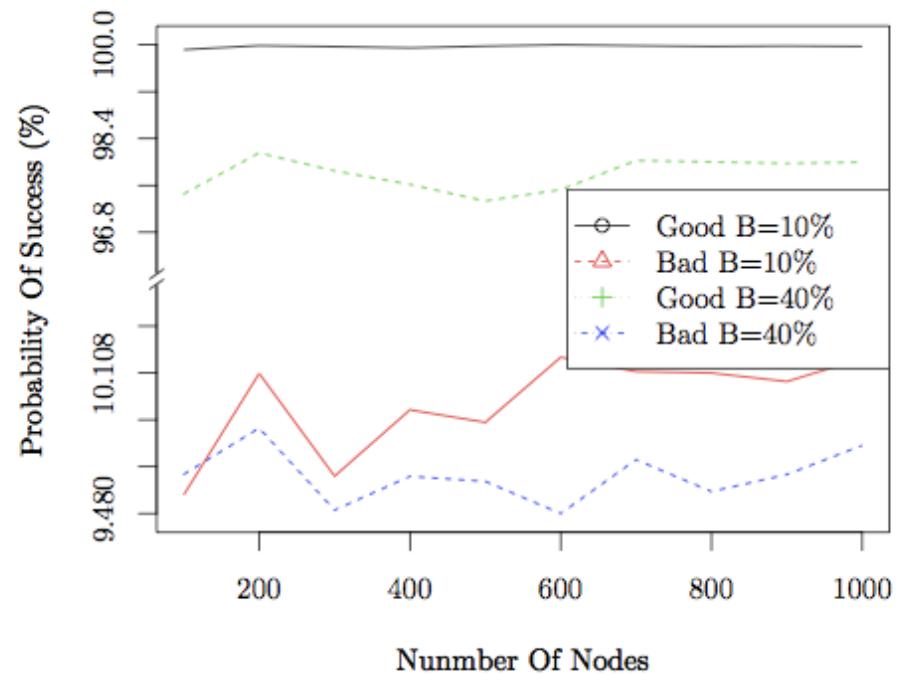
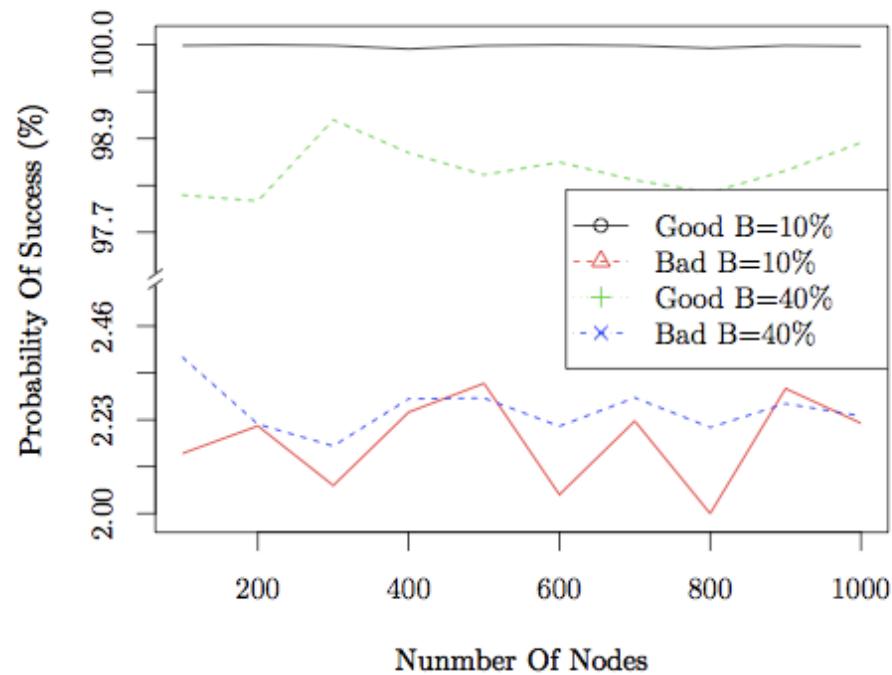
Simulation study of 100K+ nodes...



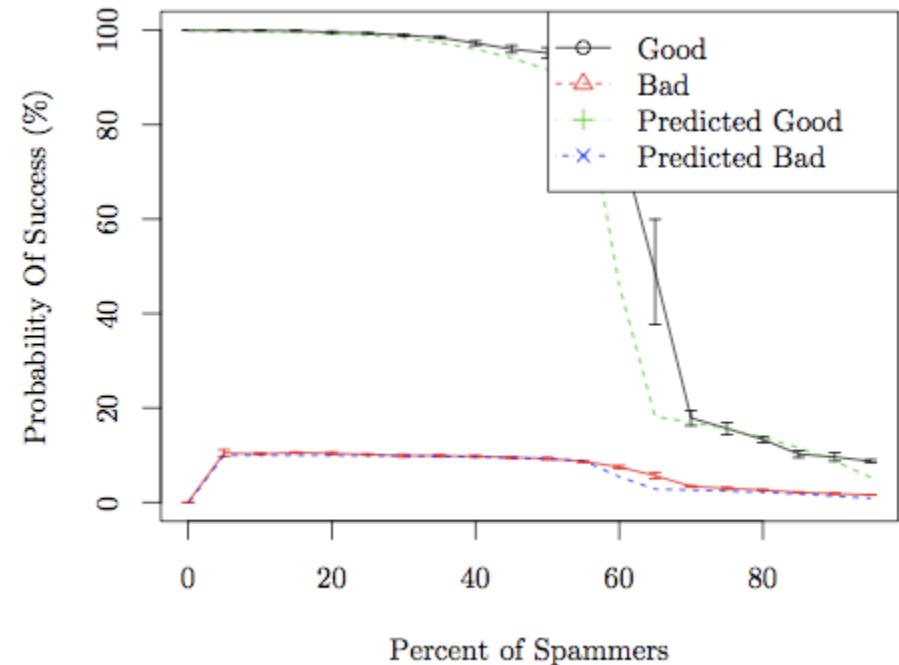
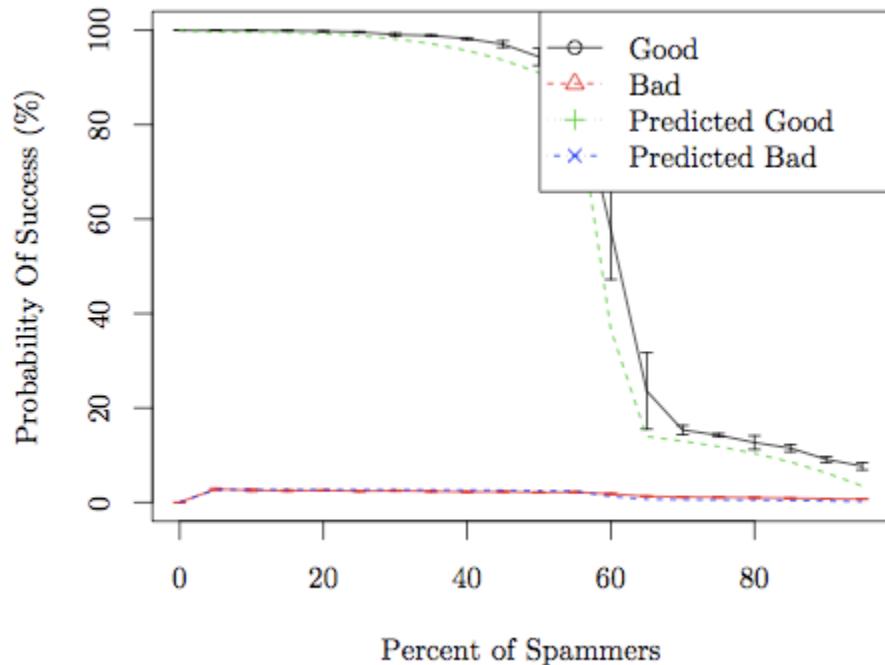
1000 nodes, 20% bad



1000 nodes, 10%/40% bad



Increasing the Spammers



$$\Pr(\text{success} | \sigma_0(s)) = \sigma_0(s) \cdot \sum_{1 \leq \delta \leq \lfloor \log(N) \rfloor} \ell(\delta) \cdot \Pr(\text{success} | \delta)$$

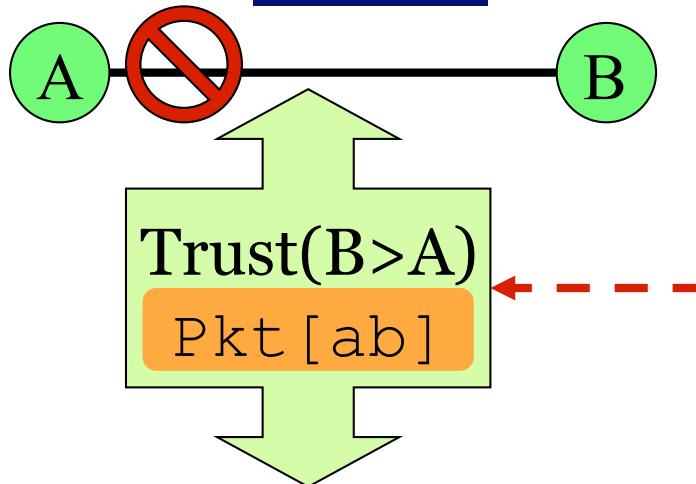
Problems with this Simple Approach

- If the attacking node already has a lot of good packets (I.e., the value of "m" is large).
- If a node was compromised for only a short period of time, it might get cut-off from the network (I.e., the value of "n" is large).
 - And, it is not that easy to produce a large number of good packets in a short period of time, plus the Prob is smaller!

Issues on Trust

- Can we avoid an “out-of-band” reset?
 - such as Credit-reset...
- The behavior of the network nodes might be very dynamic (partially good and bad).
 - There is a trade-off here...
- When the behavior is bad, how fast can our reputation system react and response?
- When the behavior is turning good, how fast can we recover its reputation? (or should we?)

Random versus Deterministic Cut-off



Algorithm 2 PROBABILITYOFDROPPING(M)

- 1: **If** PREVHOP(M) is initiator **Then** $\mathbf{A}' \leftarrow \{A_{init}, A_{rt}\}$
 - 2: **Else** $\mathbf{A}' \leftarrow \{A_{fwd}, A_{rt}\}$
 - 3: $T_{from} \leftarrow \{\min_{a \in \mathbf{A}'} T_a(u, from)\}$
 - 4: **If** $T_{from} > \tau$ **Then Return** 0
 - 5: **Else Return** RANDOM(0, 1) $> T_{from} ? 1 : 0$
-

Four Schemes

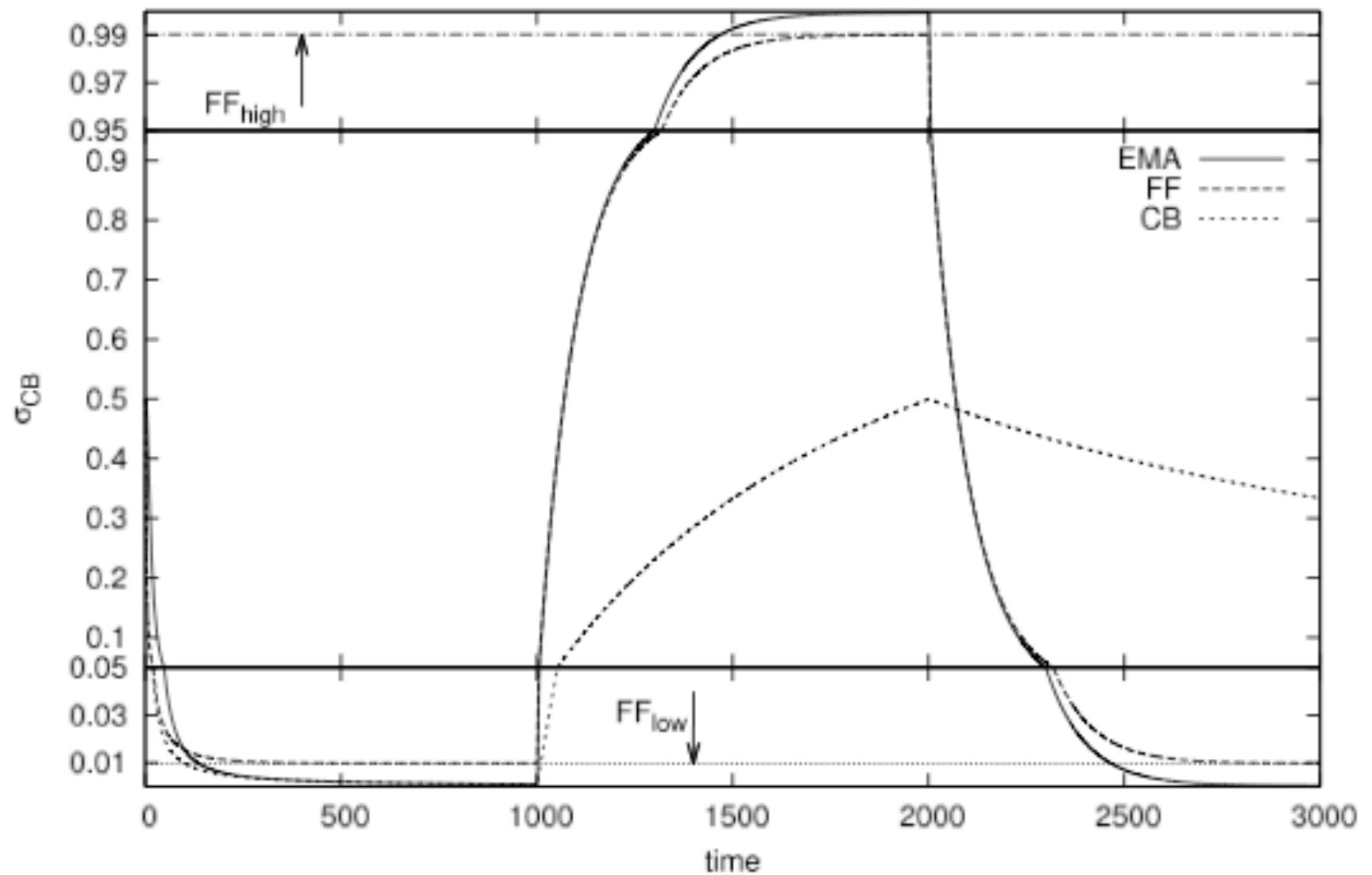
- Counter-based (CB)
- Credit-based (CR)
- Forgetting/Aging Factor (FF)
- Our enhanced version (KarmaNet)

Pairwise 1-way Trust

$$T_u^a(v) = \begin{cases} \langle C \rangle \in \mathbb{N} & (\text{TCR}) \\ \langle m, n \rangle \in \mathbb{N}^2 & (\text{TCB}) \\ \langle m, n \rangle \in \mathbb{R}^2 & (\text{TFF}) \\ \langle m, n, c \rangle \in \mathbb{R}_{[0,1]}^2 \times \mathbb{N} & (\text{TEMA}) \end{cases}$$

$$T_u^a(v) \leftarrow \begin{cases} \langle C - 1 \rangle & (\text{UCR}) \\ \langle m_{i-1} + o, n_{i-1} + \bar{o} \rangle & (\text{UCB}) \\ \langle o + \bar{\lambda}m_{i-1}, \bar{o} + \bar{\lambda}n_{i-1} \rangle & (\text{UFF}) \\ \langle o\lambda + \bar{\lambda}m_{i-1}, \bar{o}\lambda + \bar{\lambda}n_{i-1}, c + 1 \rangle & (\text{UEMA}) \end{cases}$$

where $\bar{\lambda} = 1 - \lambda$, $\bar{o} = 1 - o$, and m_{i-1}, n_{i-1} denotes the prior trust value.



KarmaNet

$$m_i = \lambda o + (1 - \lambda) \cdot m_{i-1}$$

$$n_i = \lambda \cdot (1 - o) + (1 - \lambda) \cdot n_{i-1}$$

$$\sigma = \begin{cases} C > 0 & (\text{SCR}) \\ \frac{m}{m+n} & (\text{SB}) \\ \frac{m+1}{m+n+2} & (\text{SCB/SFF}) \\ \frac{mc + m/\lambda + 1}{mc + nc + \frac{m+n}{\lambda} + 2} & (\text{SEMA}) \end{cases}$$

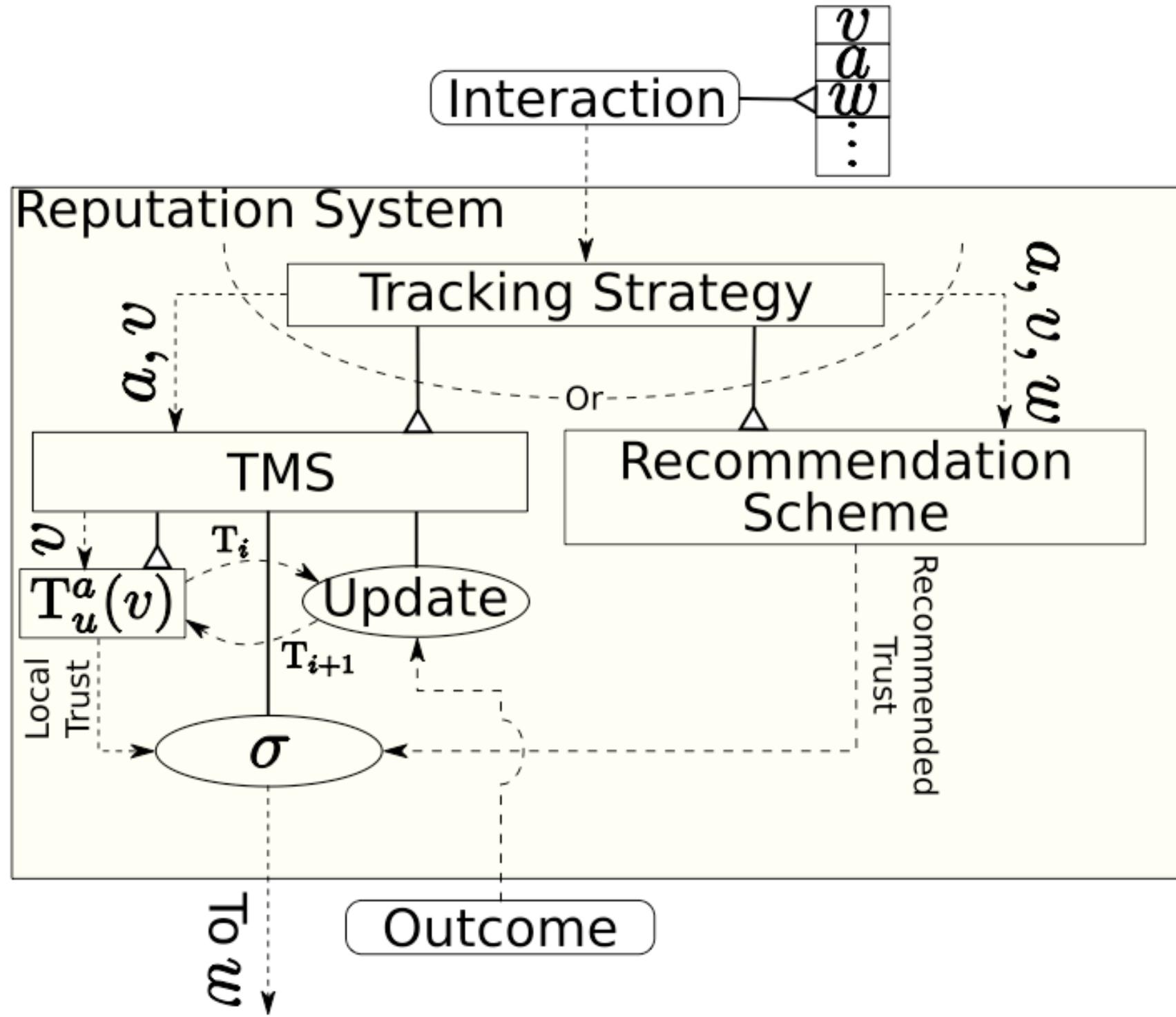
Unbounded Malicious Messages

Theorem 5: The cutoff time (the time for a node to go from an initial value of τ to ϵ) using is:

$$O\left(\frac{1}{\epsilon}\right) \quad (\text{CB})$$

$$\infty \quad (\text{FF})$$

$$O\left(\frac{1}{\sqrt{\epsilon}}\right) \quad (\text{EMA})$$



Model for Trust/Reputation Systems

- performance and responsiveness to dynamics (of trust and reputation)
 - Assuming no oracle or human reset (and we might not have ground truth in real-time anyway).
 - operations and management
- Bounded/unbounded for life-time expected attack instances
 - Versus bounded for a fix period of time
 - Probabilistic versus Deterministic

DSL is an old idea!

A

And, I certainly don't have the answer yet...

B

We, as **human**, have been using similar **social communication principles**. Maybe it is a good opportunity to re-think about our cyber communication system.

Identity is a per-application, context-oriented, and sometime relative issue.

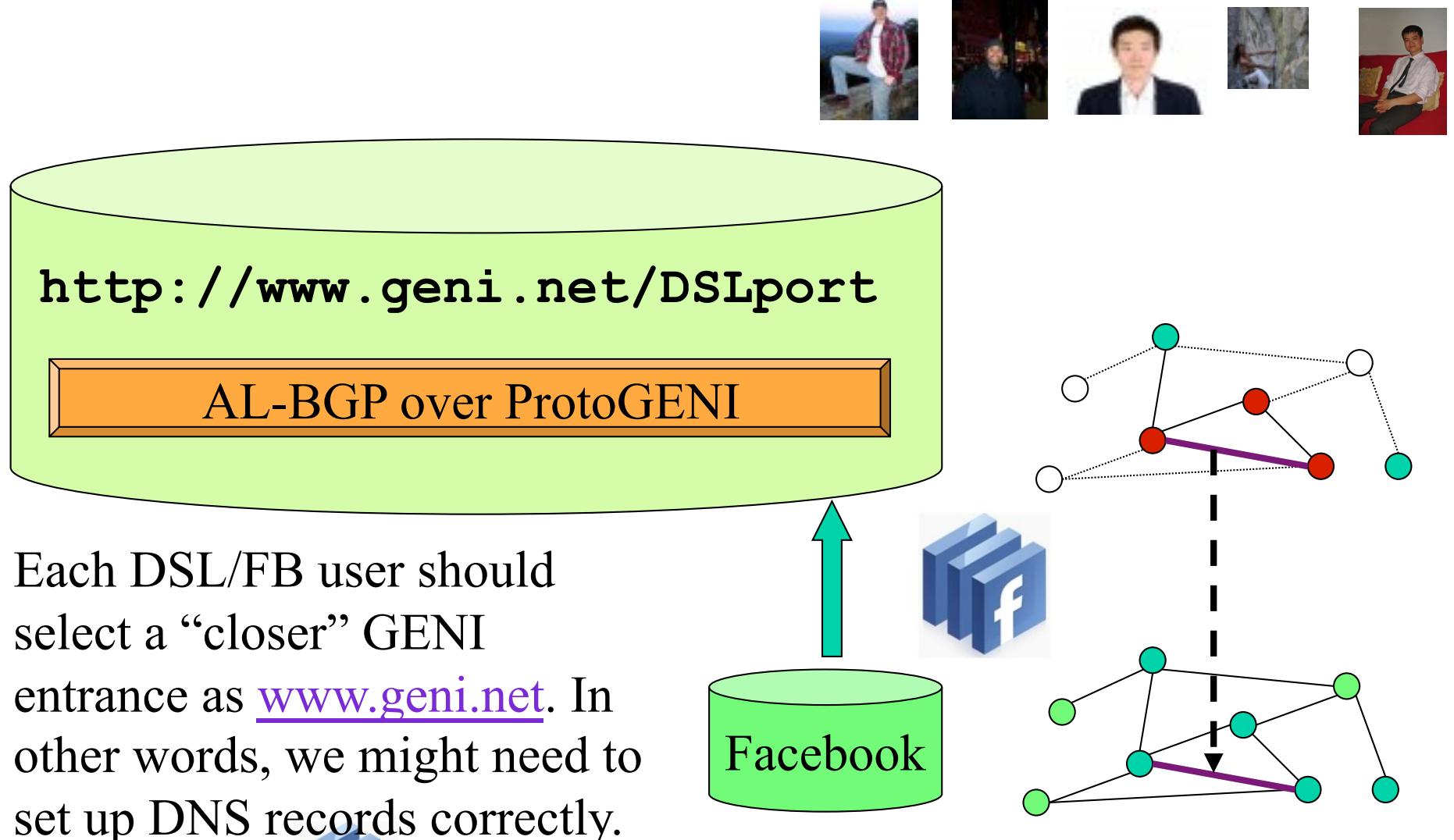
Forming cyber communities of **interests** for application.

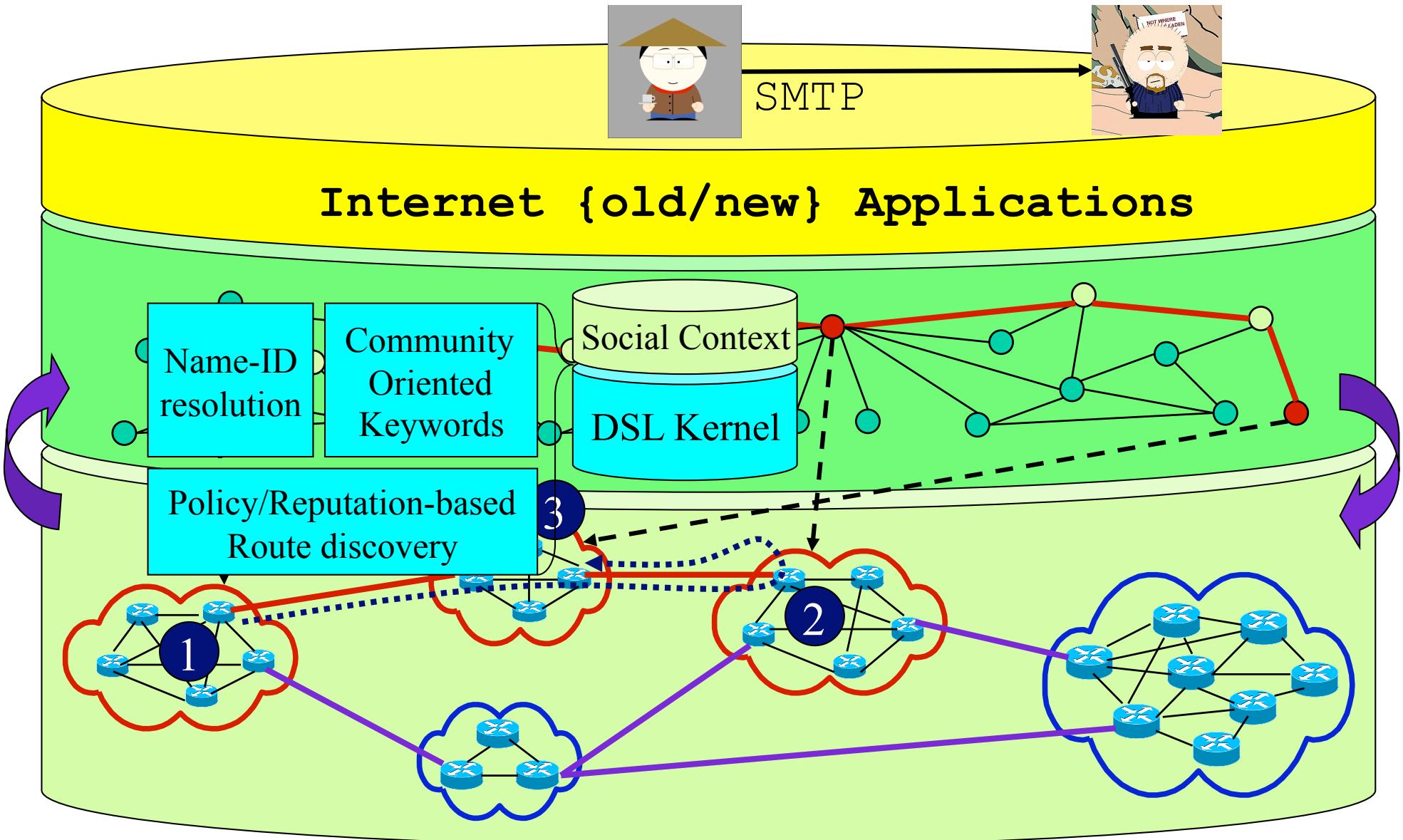


FIND

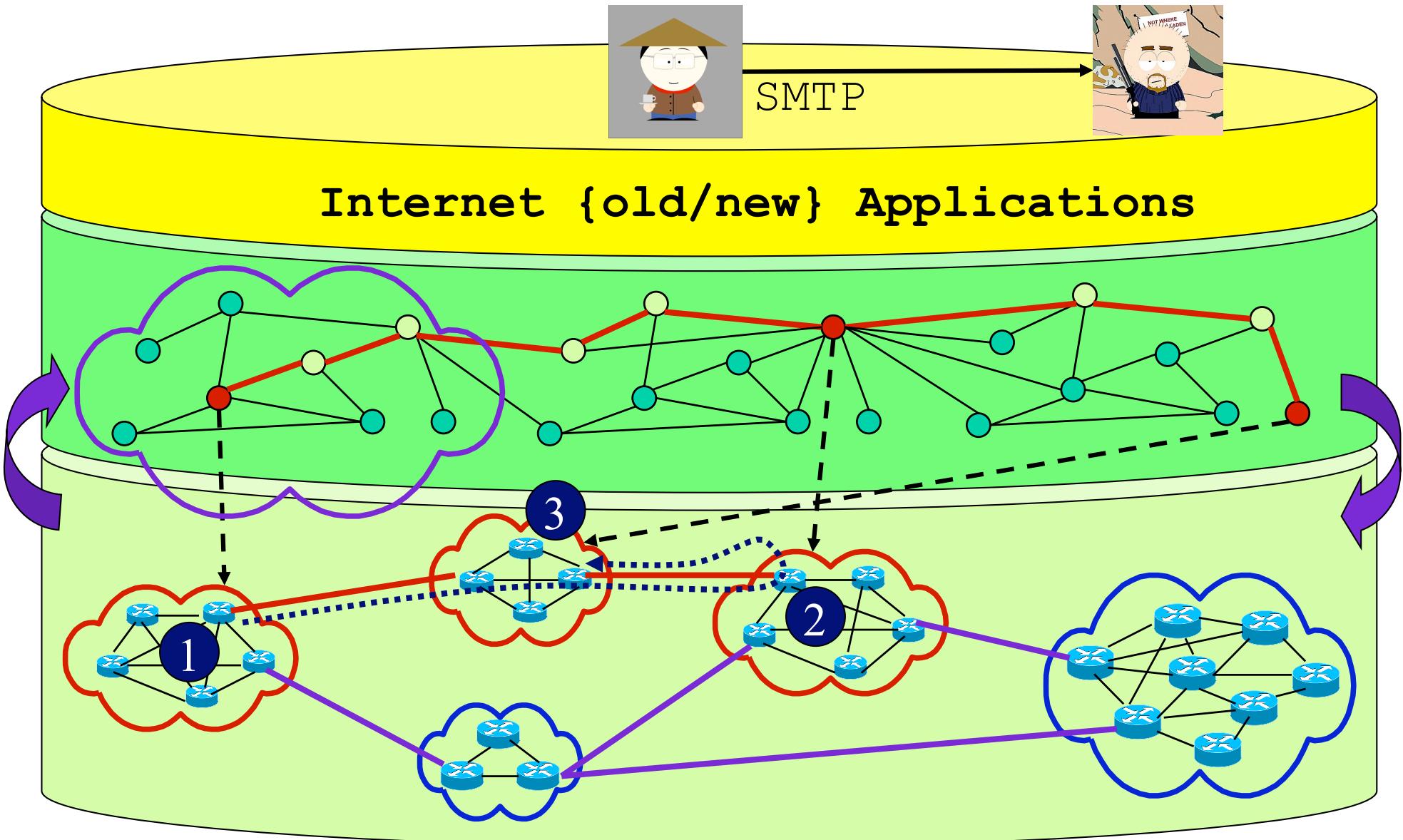
- “Involving End users”
 - Should we move away the traditional model (I.e., the end users have relative little control toward the core, even for his/her own traffic)?
 - If yes, how much and what?
- DSL:
 - Decentralized Social Network
 - Community/Keyword oriented
 - Trust/Reputation

DSL, Facebook, AL-BGP and GENI





ISP + SCSP (Social Community Service Provider)





DSL

Global

Basic Info

Type: Internet & Technology – Cyberculture
 Description: This is the DSL (Davis Social Links) project group.

Contact Info

Email: wu@cs.ucdavis.edu
 Website: <http://www.cs.ucdavis.edu/~wu/dsl/>
 Office: 3057 Kemper
 Location: One Shields Avenue
 Davis, CA

Recent News

<http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0832202>

Members

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BanksDimitri
DeFigueiredoHaixin
Duan

左浩天

Ben Y.
ZhaoBjörn Lilja
Yujie Liu[View Discussion Board](#)[Message All Members](#)[Promote Group with an Ad](#)[Edit Group](#)[Edit Members](#)[Invite People to Join](#)[Create Related Event](#)[Leave Group](#)[Share](#) +**Group Type**

This is a closed group. Members must be invited or approved by an admin.

Admins

- S. Felix Wu (creator)