Usable Security:
Oxymoron or Challenge?

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Quiz

- Do you have more passwords/PINs than you can remember?
- Have you ever gotten a phishing email?
  - *Have you ever gotten an email message where you weren't sure whether it was phishing or not?*
- Have you ever needed to do something but couldn't because you:
  - didn't know the password/key/PIN
  - couldn't get through the firewall
  - the permissions were set wrong
- Have you ever been asked a question by a piece of security software *that you couldn't answer?*

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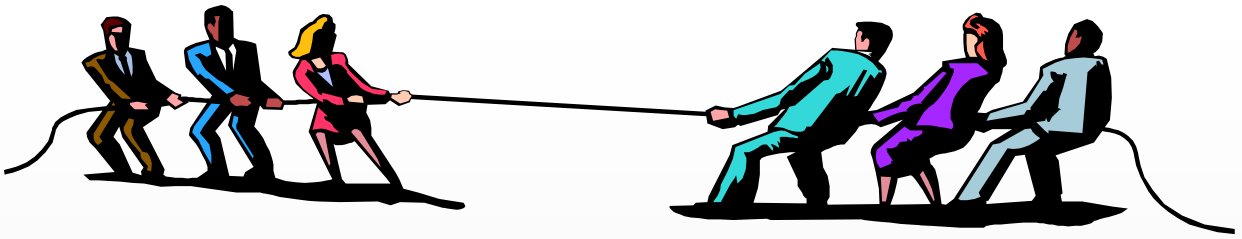
Problem



- Usability and security often seen to be at odds
  - if security gets in the way of getting work done people will turn it off
- Most deployed security technology not designed with usability in mind
  - security seen as far more important
- Can't add usability in "after the fact"
  - any more than you can security
- New realities require that you have both
  - no longer any safe spaces where you can ignore security
  - simply not cost-effective to ignore usability
    - » end user often the only one in a position to make security decisions
    - » systems are designed primarily to get real work done, not just to be secure

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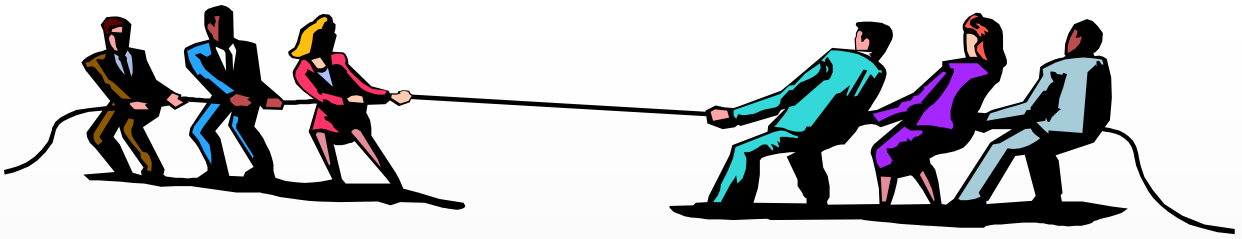
Approach



Research Question:

If you put usability first, how much security can you get?

- **Design security technologies that make usability easier**
  - reuse existing technology when appropriate
  - change it when it is not
    - » Don't just "make passwords better"
    - » Adding a better GUI to badly designed technology almost never good enough
- **Test systems with real users**
  - security researchers almost never have accurate intuitions about what is "usable"
- **Involve interdisciplinary project teams**
  - both security researchers and HCI researchers/fieldworkers

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Things not to do: Passwords

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Passwords

- cheap(er) and easy to implement
  - *so everybody uses them everywhere*
- people have trouble remembering them
  - *choose bad ones*
  - *reuse them*
  - *write them down*
- systems administrators try to compensate
  - *password quality rules*
  - *password change requirements*
  - *password lockouts*
- once you give them away, they're gone
  - *phishing attacks and other forms of social engineering*
  - ***no easy way for user to authenticate server***

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How to make passwords more usable?

While not making them less secure?

Easy places to start:

- increase password lockout thresholds (e.g. 3->10)
  - *doesn't significantly change attacker's ability to brute force passwords*
  - *does dramatically drop lockouts from, e.g. CAPS LOCK*
- don't require frequent password changes
- **decrease the number of passwords people have**
  - *don't require passwords when you're not protecting anything*
    - » *e.g. accounts whose purpose is customer identification, not data protection*

These help usability, but not security.

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Can we make passwords easier to remember, but not easier to guess?

- phrase-based mnemonic passwords (Yan, et al '05)
  - *pick the first letter of each word in a phrase*
    - » *& for "and", 4 for "four", etc.*
    - » *e.g. "Four score and seven years ago, our fathers" -> 4s&7ya,of*
  - *easier to remember than random passwords*
  - *as resilient to cracking attempts using standard dictionaries*

- graphical password systems (too many to mention)
  - *e.g. select a set of points in an image and select them again later (PassPoints)*
  - *…and many more*

Can we make passwords easier to remember, but not easier to guess?

No. We are too predictable.

- phrase-based mnemonic passwords
  - *everybody turns out to pick the same phrases (Kuo et al '06)*
    - » *"Oh I wish I were an Oscar Meyer Wiener…"*
  - *just make a phrase-based cracking dictionary*

- graphical password systems
  - *e.g. select a set of points in an image and select them again later (PassPoints)*
  - *everybody turns out to pick the same sets of points…*
    - » ***can build "graphical cracking dictionaries"***

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What else can we do?

- two-factor authentication
  - *give users something else they need to present*
    - » *physical token, securid value, etc…*
    - » *typically implemented with **One-Time Passwords***
  - **attackers mount online "Man-in-the-Middle" attacks**
    - » *get the one-time password, present it to the server, give an error to the user*
- make it possible for user to authenticate server
  - *user picks a personal image, should only give password to server that knows the image*
    - » *SiteKey, Security Skins (Dhamija et al, '05)*
  - ***turns out users don't notice if image is missing** (Schechter et al '07)*

What else can we do?

- enlist software to help
  - ***browsers that attempt to recognize and discourage use of illegitimate sites***
    - » *IE7, Firefox, you name it*
    - » **depends on how strongly they "discourage"**
  - ***better brands of password managers***
    - » ***beyond just "adding a better GUI to passwords"***
    - » *keep users from reusing passwords*
    - » *automatically generate per-site strong password*
    - » *require users to remember only one master password*
    - » *warn/prevent users if they try to enter passwords into incorrect sites*
    - » *PassPet (Yee, et al '06), WebWallet (Wu et al '06)*
    - » ***requires users to use them***
      - *lots of variants available, with wide range of security properties – how is a user to pick?*
    - » ***still vulnerable to keyloggers, etc***

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Example: Securing a Wireless Network

Balfanz, Durfee, Grinter, Smetters, and Stewart

Usenix Security 2004

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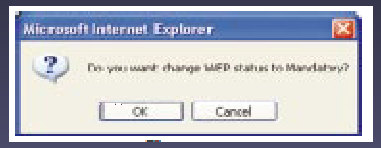
Wireless Usability versus Wireless Security

WEP: "Easy" but not secure



Turn WEP on…

…generate and select keys…

…configure cards and AP

WPA-PSK: More difficult, still has security problems

`0xa47a3471fbc843149038…`

Turn WPA on…

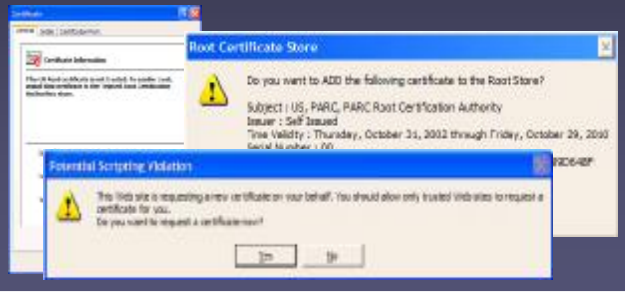
`0xa47a3471fbc843149038…`

`0xa47a3471fbc843149038…`

…configure cards and AP with long hex keys

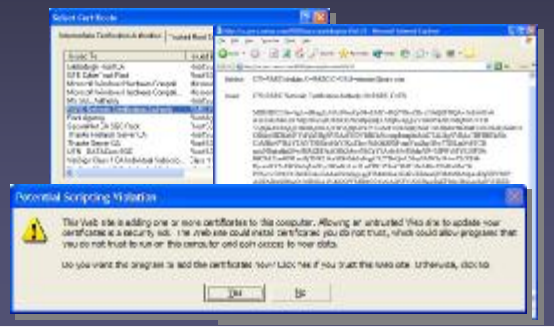
802.1x (EAP-TLS): Today's best available wireless security is too hard

User Generates Keys, Obtains Root Cert, Requests Certificate…



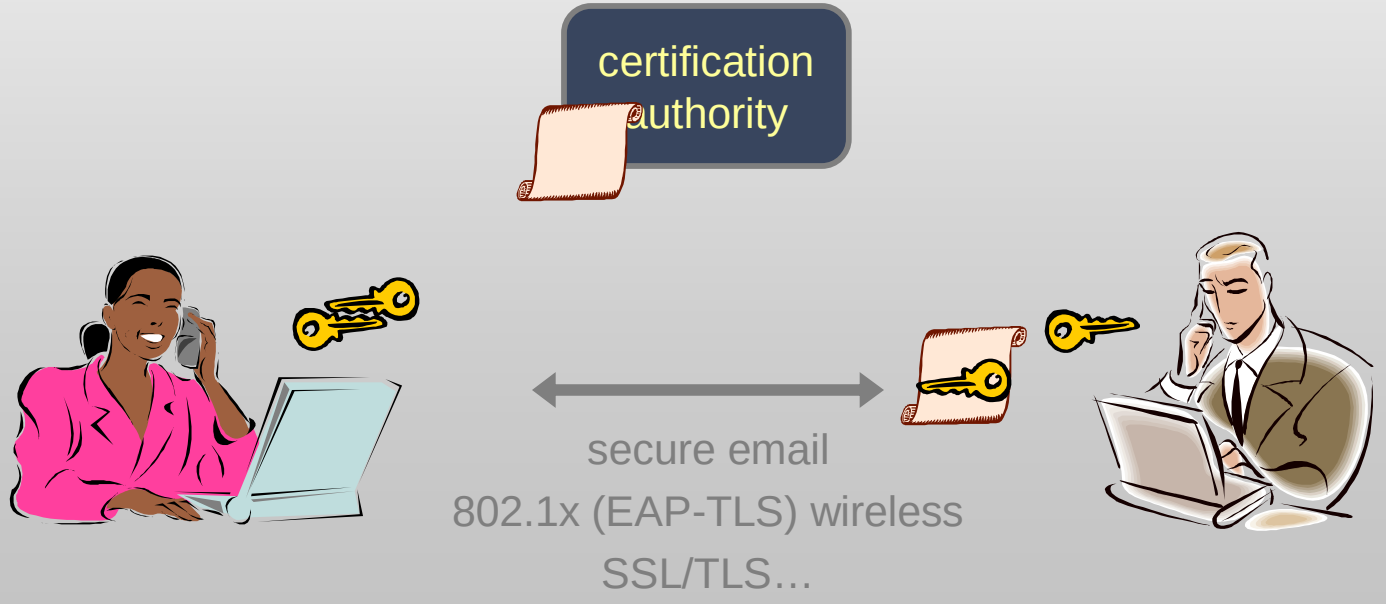
…Registration agent approves request…

…User Receives & Installs Certificate



Public Key Infrastructures

- Public Key Infrastructure technology can improve security and mitigate usability problems *once it has been deployed*.
  - Participants must generate key pairs
  - Public keys are digitally signed by a certification authority
  - Participants get *digital certificates* for authentication, encryption, …



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38 Simple Steps for Enrolling in a WLAN with PKI-Based Security

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Usable Wireless Security

How do we build a highly secure wireless network easy enough for any user to set up?

- What does the user have to do?
  - Get an access point (AP) and turn it on
  - Tell her laptop which network to join
  - Tell the AP it's okay for her laptop to join that network
    - » can skip these last two steps (and just "fall" onto the network), but not with any security
- User should do no more than this.

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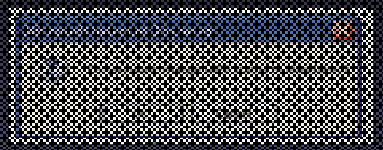
Wireless Security

WEP: "Easy" but not secure



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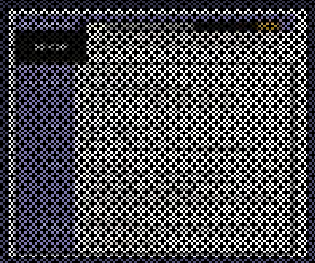

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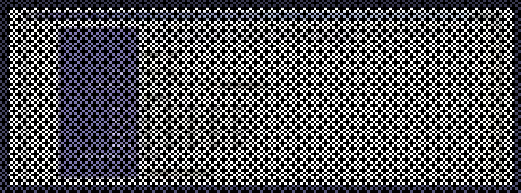
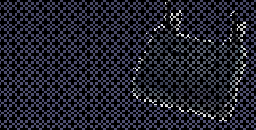
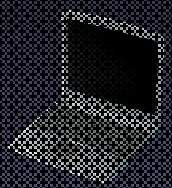


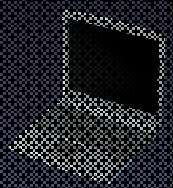
…configure cards and AP

WPA-PSK: More difficult, still has security problems



Turn WPA on…

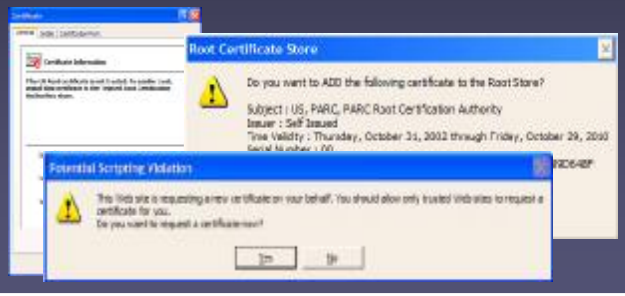




…configure cards and AP with long hex keys

802.1x (EAP-TLS): Today's best available wireless security is too hard

User Generates Keys, Obtains Root Cert, Requests Certificate…



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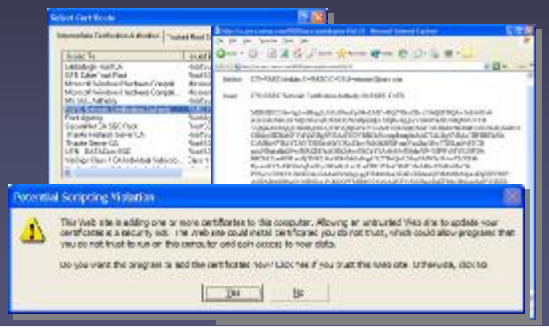
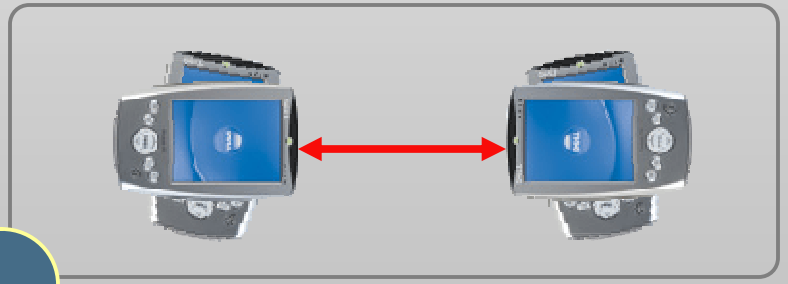


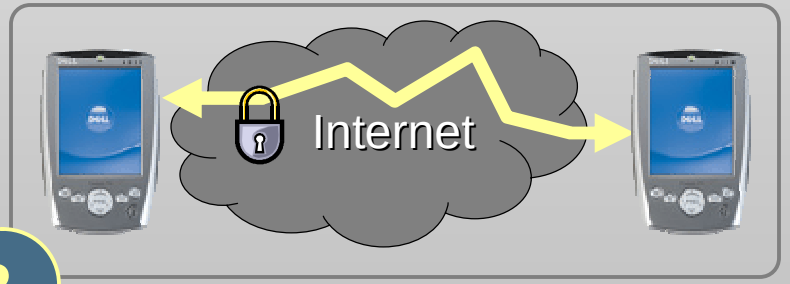
Authentication in Ad-Hoc Networks

Establishing secure communication requires *identifying communication partners* and *sharing trust information*

- Gesture-Directed Automatic Configuration
  - Intuitive gestures, e.g. pointing, identify communication partners
    - » "I want this handheld to speak to that printer"
- Location-Limited Channels (LLC)
  - Bootstrap trust from proximity: exchange cryptographic keys over out-of-band/secondary channel (IR, contact, audio, bodynet, etc…)



1. Use LLC to exchange addressing information and bootstrap trust



2. Find and communicate securely over any network

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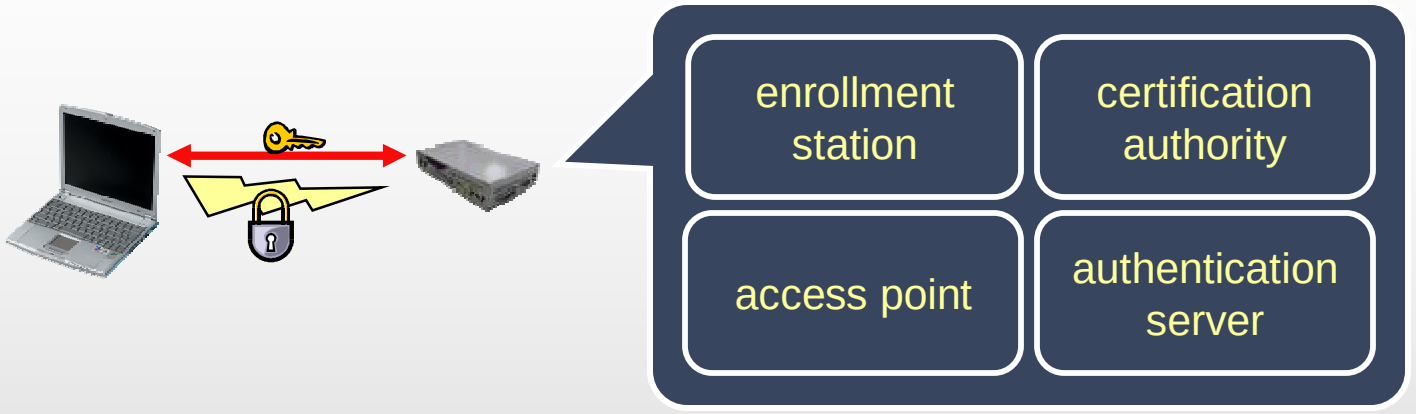
“Network-in-a-Box” (NiaB)

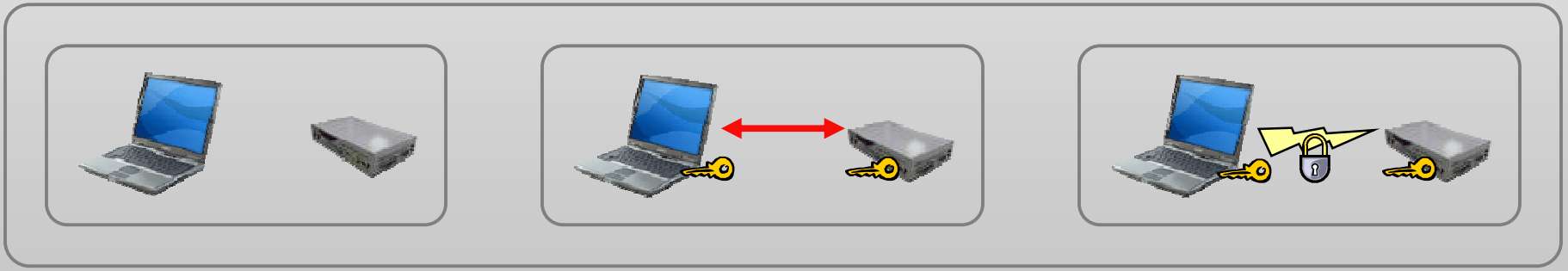
(Ballanz, Durfee, Grinter, Smetters, Stewart 2004)



- NiaB Access Point plays all key roles in 802.1x network:
  - automatically configures itself on first boot
    - » generates SSID for wireless network
    - » generates key pair & root certificate for Certification Authority
    - » configures and starts authentication server, access point, and web-based configuration and monitoring services
  - provides location-limited enrollment mechanism
    - » IR or USB based

Joining a Secure Wireless Network

1. Introduce laptop to access point using infrared
   - *Capture user intention to add this device to that network*
   - *Relate digital security to physical security*
2. Certification authority issues digital certificates
   - Automatic configuration: no input from user required
3. Laptop joins 802.1x-authenticated wireless network
   - Best wireless security available



Sets up a secure wireless network in under a minute

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Joining a Secure Wireless Network

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User Experience

- We conducted usability tests to compare a commercial Access Point (AP) against NiaB.
  - Results showed NiaB took less time, and fewer configuration steps

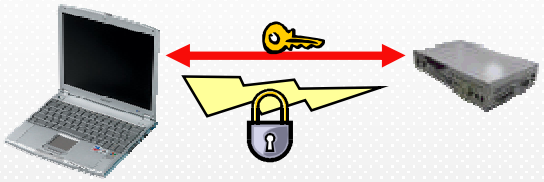
System	Time (min)	Steps
Commercial AP	9:39	14
Network-in-a-Box	0:51	2

  - Users rated NiaB *(1 = most positive, 5 = most negative)*
    - » easier to use
    - » a more satisfying experience (satisfaction)
    - » more confident that they configured security correctly (confidence)

System	Ease of Use	Satisfaction	Confidence
Commercial AP	3	3	2
Network-in-a-Box	1	1	1

Enterprise-Scale NiaB

Network-in-a-Box



enrollment station

certification authority

access point

authentication server

Enterprise NiaB

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enrollment station

certification authority

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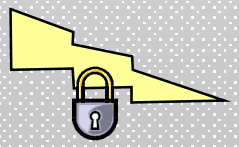

access points

authentication server

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Enterprise-Scale NiaB

- Simple, intuitive enrollment mechanism
  - User walks down to “enrollment station”, lines up IR, leaves.
- Simple, intuitive trust model
  - Users must request access to locked enrollment station room to request their wireless certificates.
- Certificates bound to capabilities, not identities
  - Certificate used for wireless access only
- No need for direct user interaction with certificates
  - Wireless clients are set up to use new certificates automatically, and to renew them when they expire

User Experience

- We conducted usability tests to compare traditional PKI + 802.1x enrollment against Enterprise NiaB.
  - Results showed ours took less time, and fewer configuration steps

System	Time (min)	Steps
Traditional PKI	140:00	38
Enterprise NiaB	1:39	4

  - Users rated NiaB *(1 = most positive, 5 = most negative)*
    - easier to use
    - a more satisfying experience (satisfaction)
    - more confident that they configured security correctly (confidence)

System	Ease of Use	Satisfaction	Confidence
Traditional PKI	5	4	4
Enterprise NiaB	1	1	1

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Conclusions

- Can build practical systems that are highly secure and highly usable
  - Don’t assume you know what is usable
    - Security researchers are not good models for “typical” users
  - Use existing security tools when appropriate
    - PKI
    - Standard security protocols (802.1x, WPA, TLS)
  - Think about them in a different way
    - Small-scale “Instant” PKI
    - Authentication via physical proximity
    - Transparently automate handling of both security and wireless settings
      - users don’t think of security and management as separate activities

A Few General Principles

(Everybody's got to have a set…)

- Implicit Security
  - if an explicit user request requires security changes to effect, don't make them ask again
    - » no separate but (un)equal security interface
    - » doesn't mean security must always be invisible, just that it ought to be when it can
- "And Nothing Else" Security Policy
  - easy and intuitive metric for what a system ought to do
- Who are the users?
  - usability also impacts developers, designers, administrators…
- User decisions should be framed in terms of application tasks
  - that is all that they care/know about
  - pushes security back up to the level of the application
- Users don't need to know and love your abstractions
  - "share the pain" not a good design mindset

Thank you!

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Extra Slides

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Example: Secure Access to Remote Resources

Smetters, Balfanz, Durfee, Smith and Lee

Ubicomp 2006

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The Problem

Want to seamlessly integrate and *personal* data and computing environments…

Work

Home

Family/Friends

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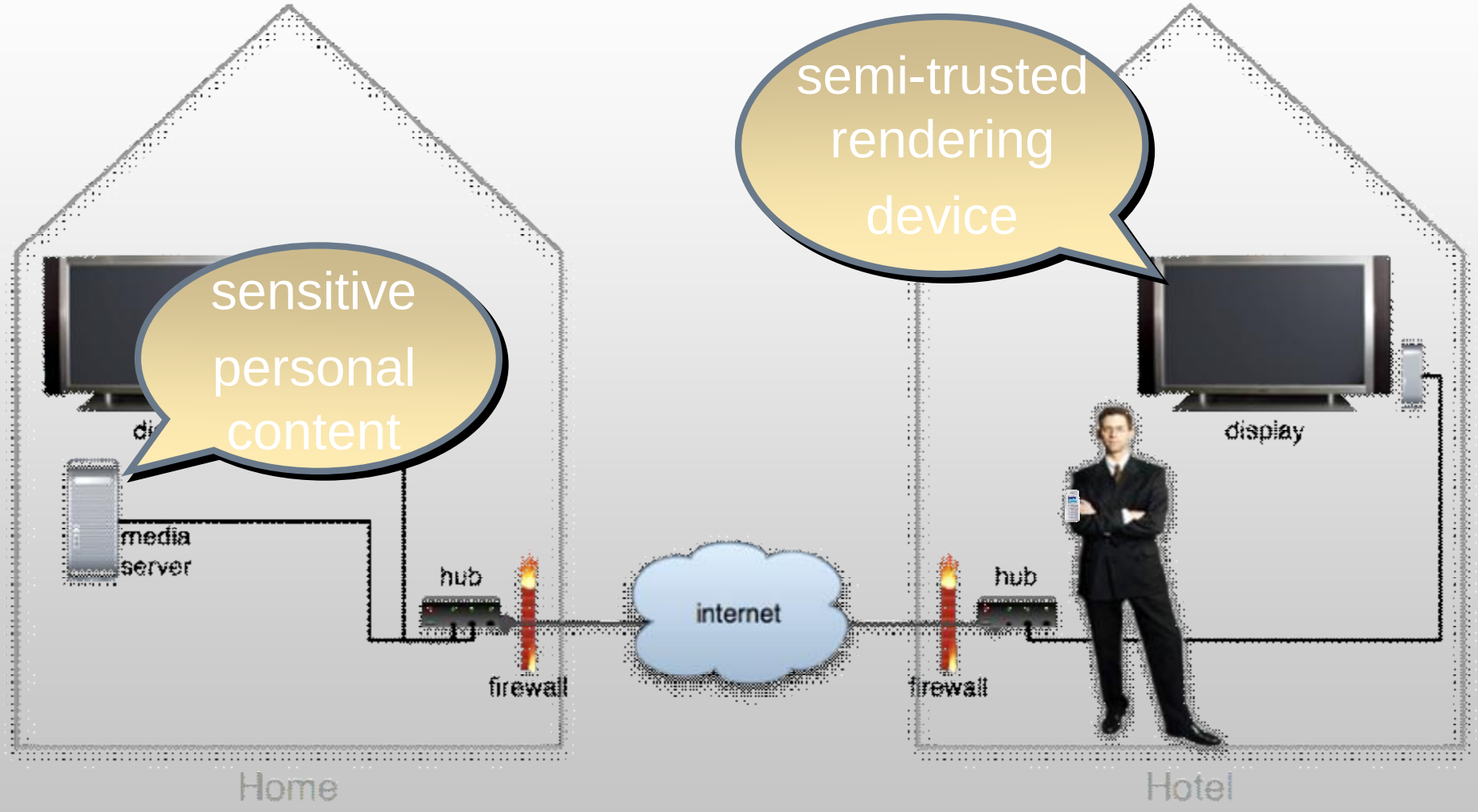
Our scenario



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Our scenario

Requirements

- functionality
  - opportunistic access to encountered resources
  - universal access to personal resources
    - » no need to specify access policy *a priori*
  - minimize required user effort
- security
  - least privilege access boundary
    - » only the device the user selects can access
    - » can only access the resources the user indicates
    - » ***"and nothing else" policy***
      - implies requirements for authentication, encryption, etc
  - reliable and secure indicators of user intent
    - » implicit security
    - » ***trusted input path***

The Solution

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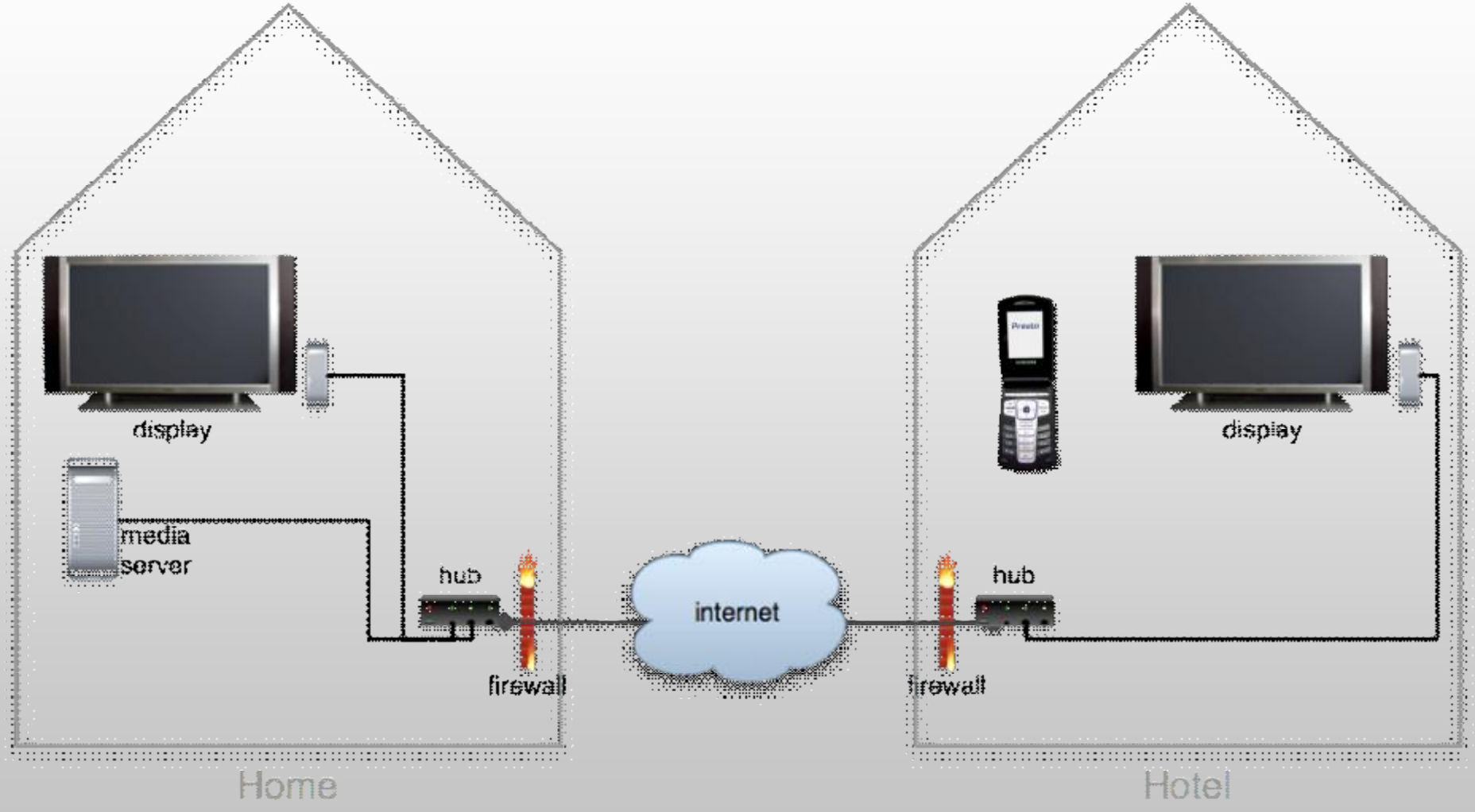
Our Solution



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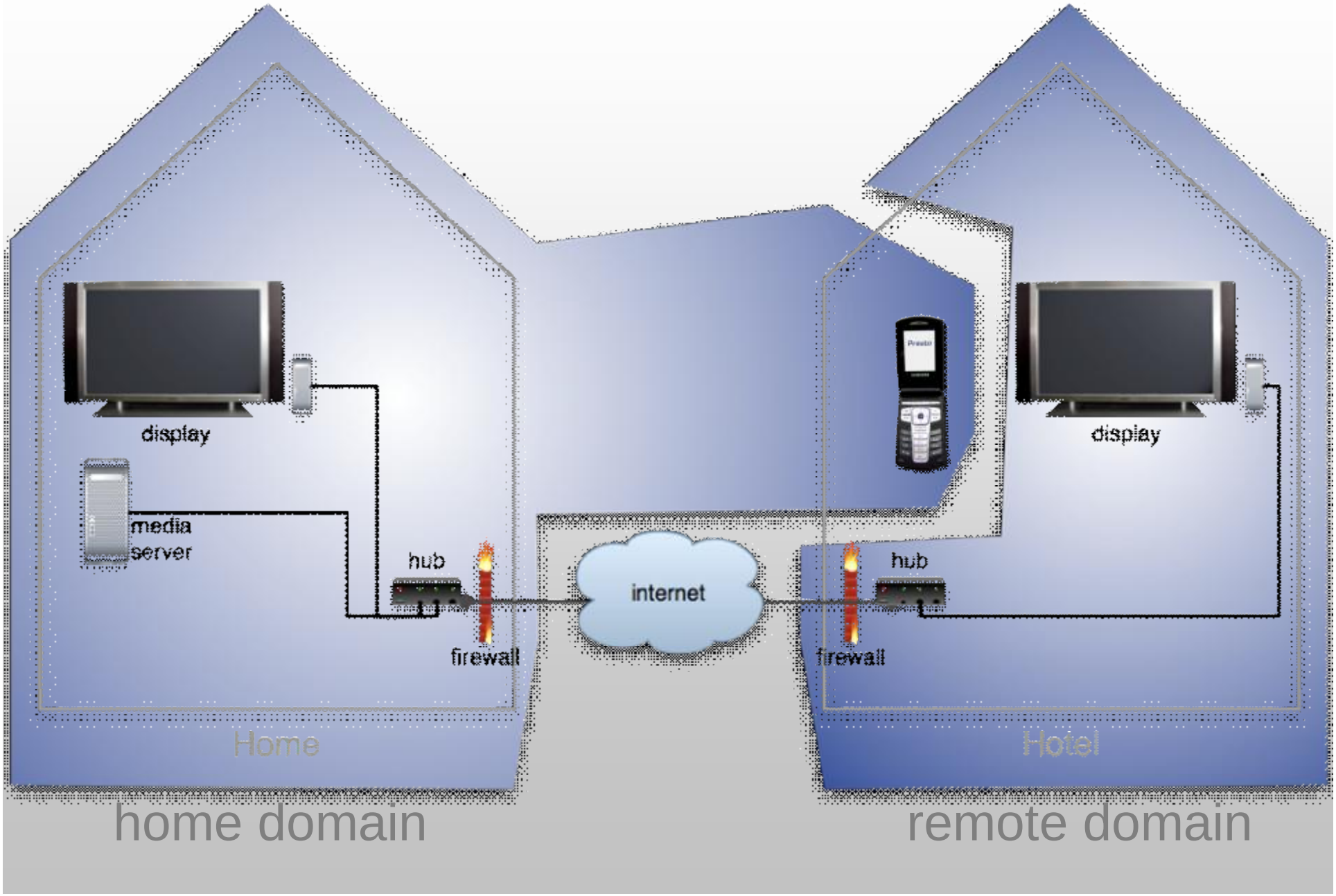
Security by Introduction



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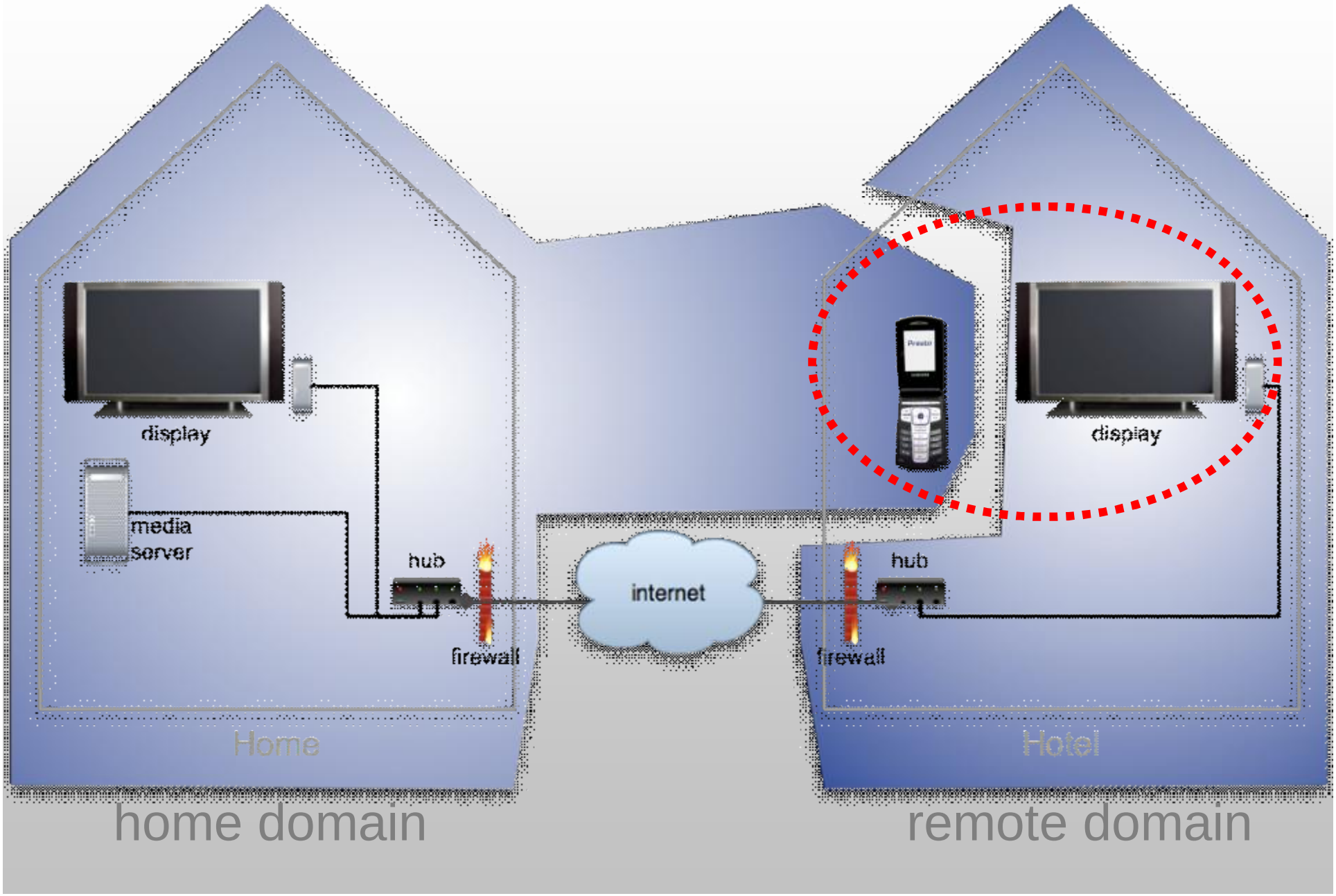
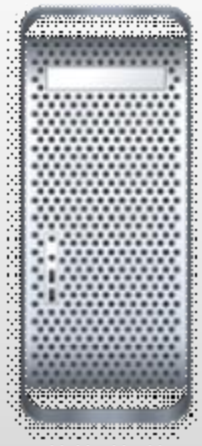


Instant Matchmaker as Security Mediator



trusted resource

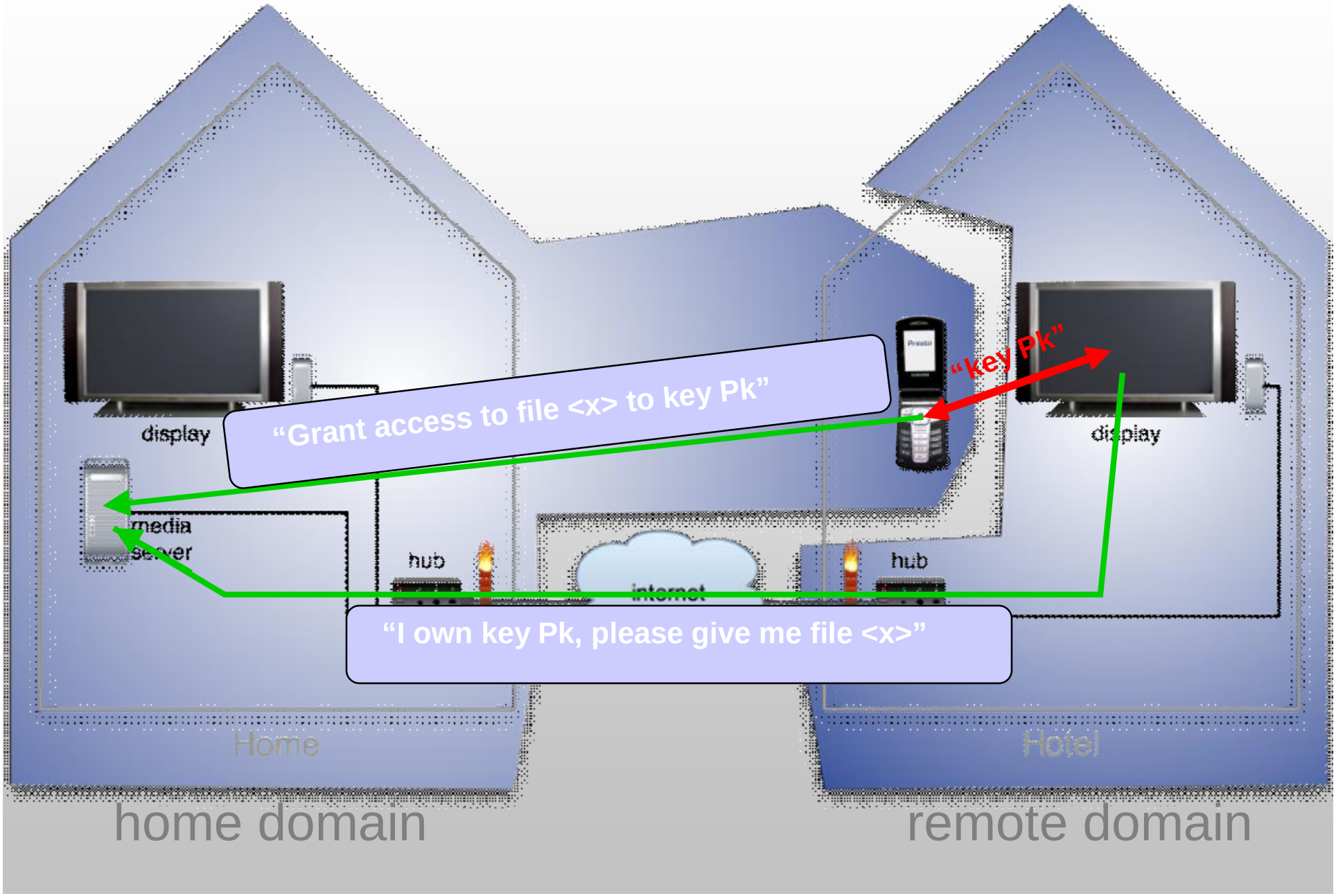
untrusted access device

long-term trust

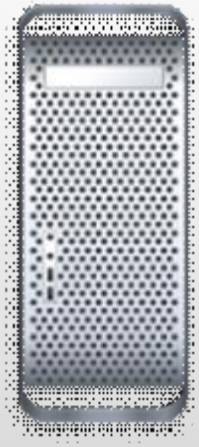
proximity

instant matchmaker

Security by Introduction



Demonstration System



trusted home resource media store

untrusted local TV device

local (“instant”) PKI

key exchange over infrared

802.11a/b/g handheld phone

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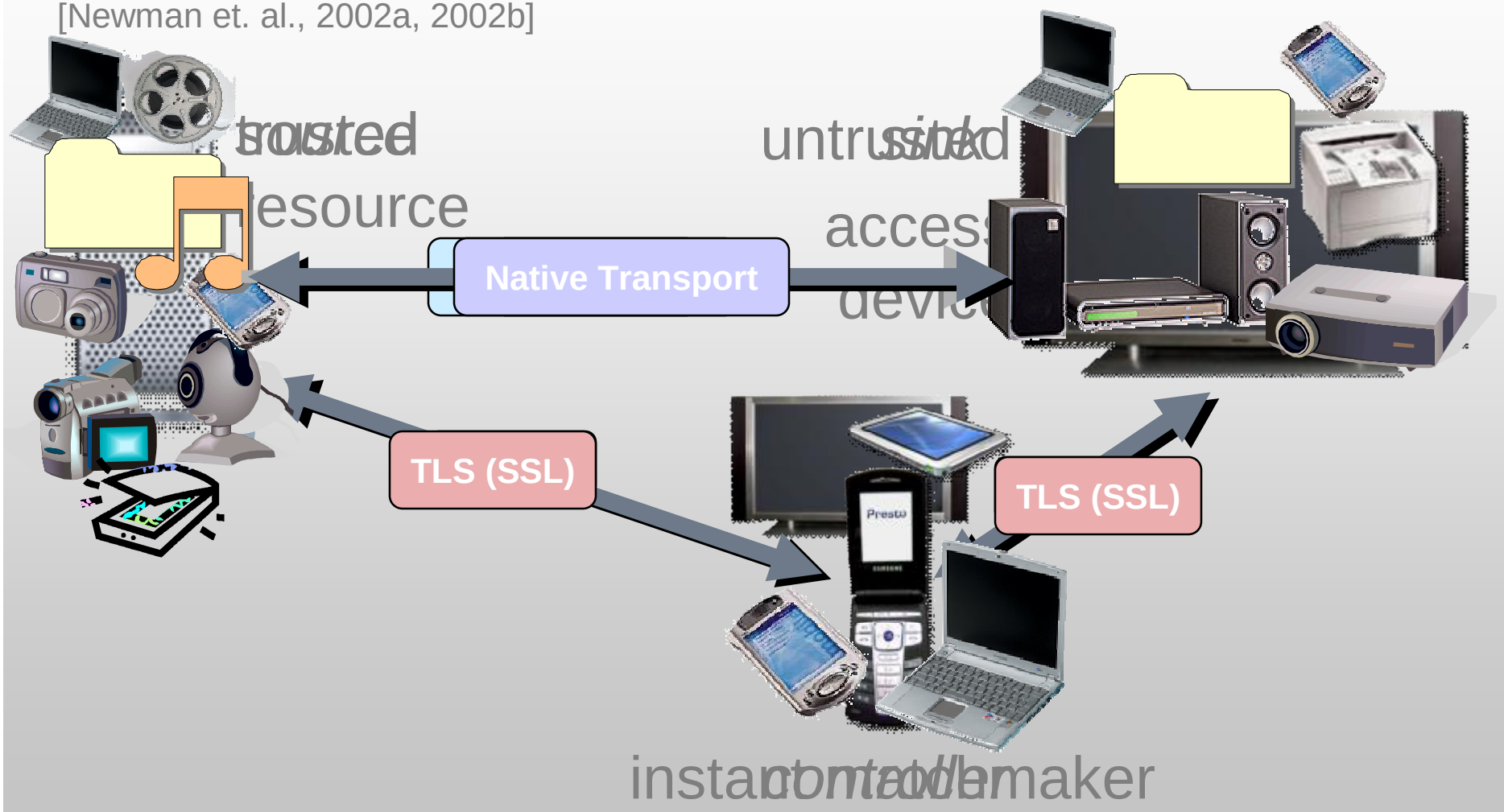
Obje (Speakeasy): Middleware for Radical Interoperability

[Edwards et. al., 2002]

[Newman et. al., 2002a, 2002b]



Establishing Trust

- embed public key information in infrared exchange
  - in this case, use phone as remote control to turn on TV
- establish secure connection and limited trust between phone and nearby display

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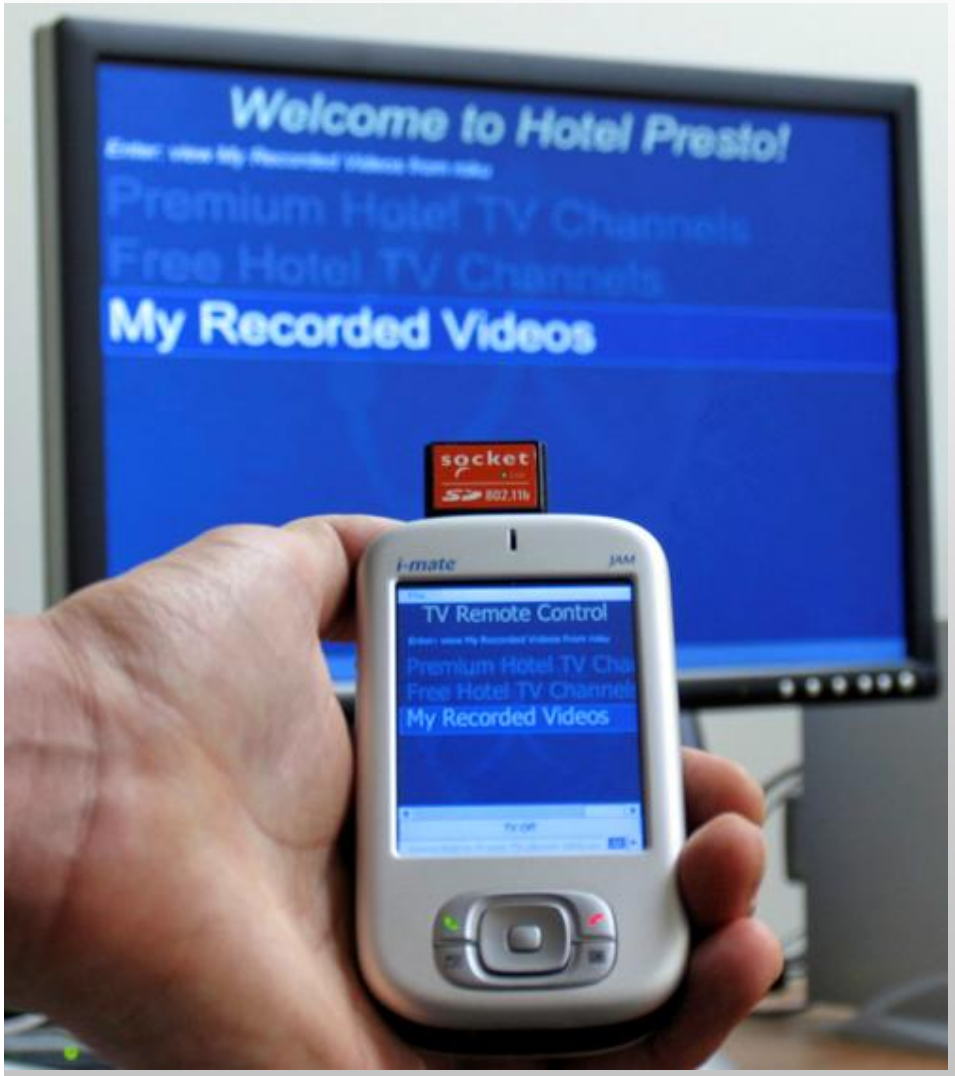
Determining Intent



Trusted input path: gathering all input via the trusted matchmaker device gives reliable indicator of user intent.

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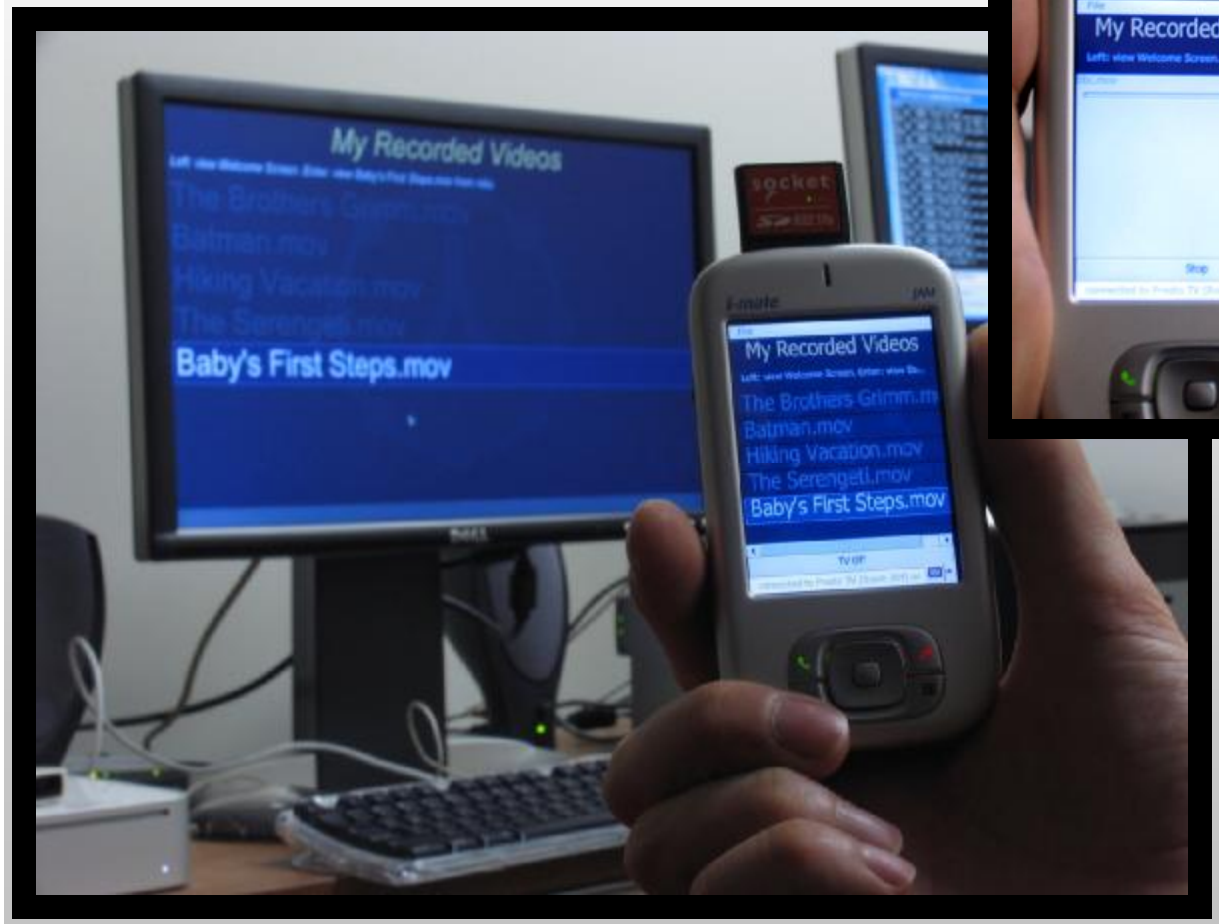
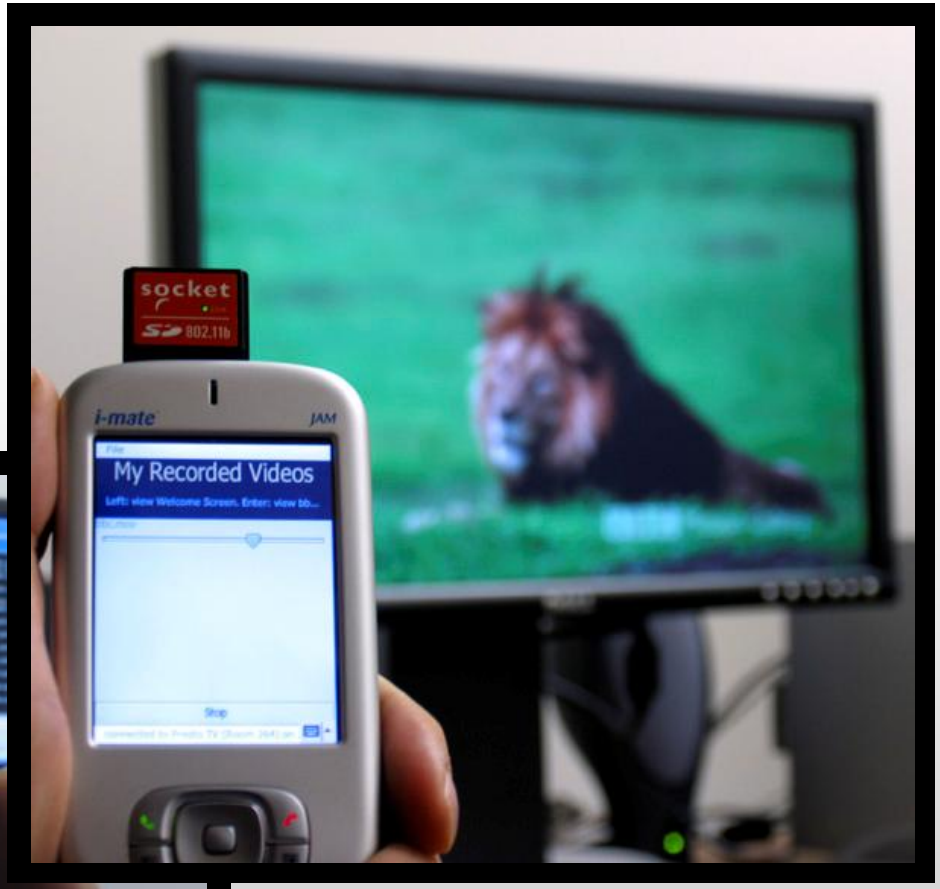
Granting Access





Selecting “Play”: designated device is allowed to play user-selected piece of content **one time**.

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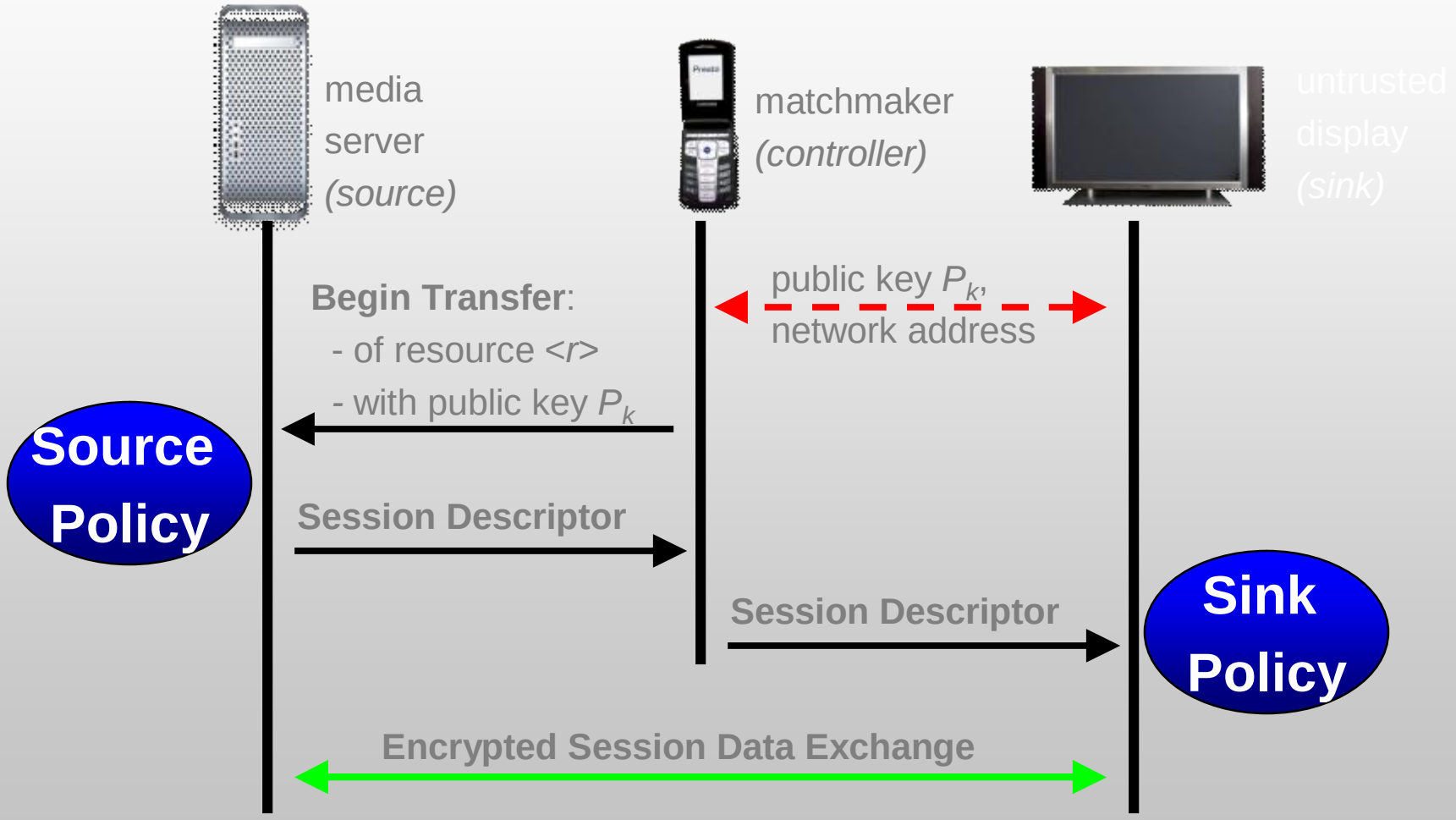
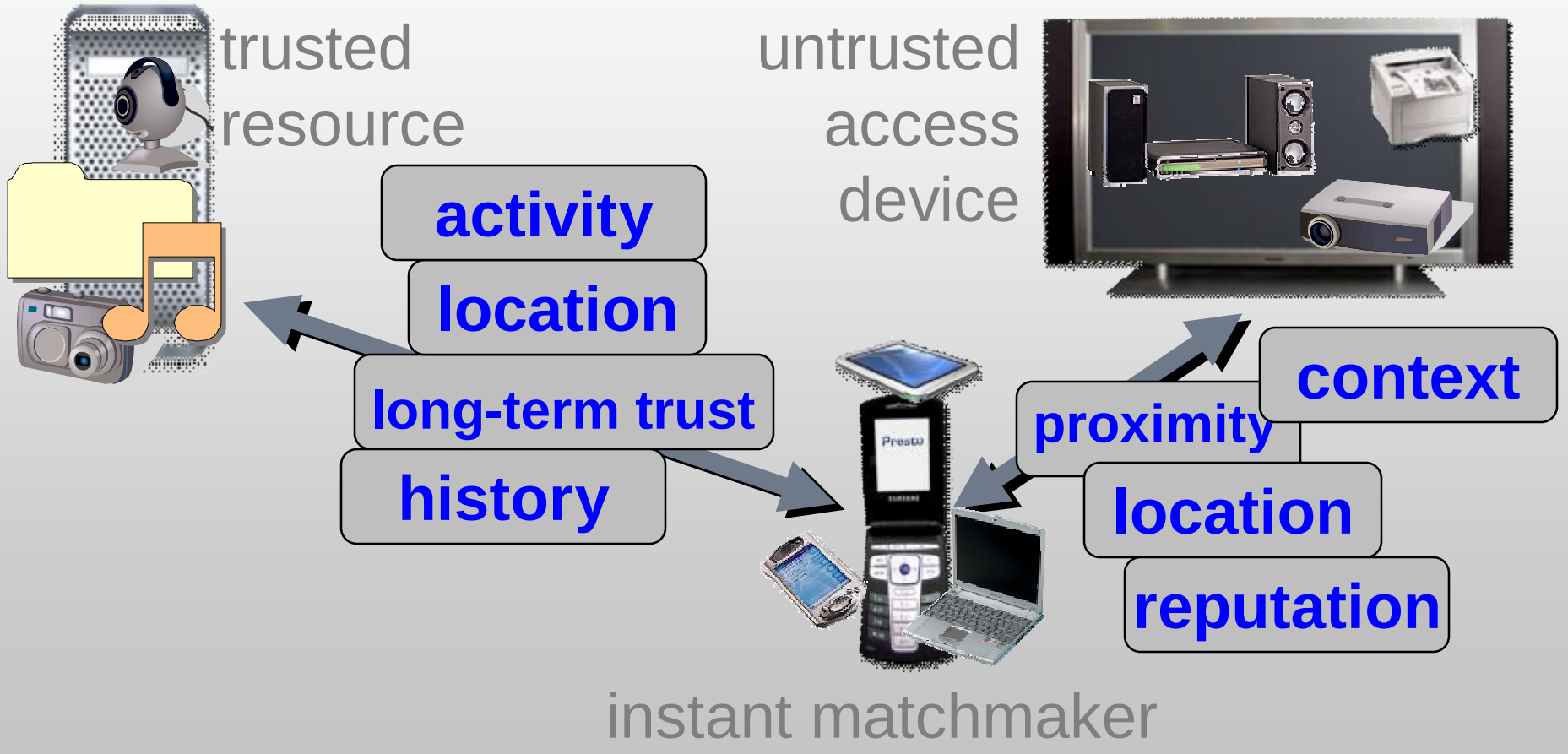
Obje Dataflow



Meta-Policies

Access Control Point	Home Device	Instant Matchmaker (TV Remote)	Hotel TV
Source Policy	Allow session with any sink, *as long as controller is from home domain*. *(instant matchmaker policy)*	Only allow a session where controller is IM itself and sink is IR-authenticated local device *(for mirroring GUI)*	Only allow sessions with TV in source role if TV is also the sink. *(allow playing local content)*
Sink Policy	Allow session with any source, *as long as controller is from home domain*. *(instant matchmaker policy)*	No sessions in sink role allowed.	Allow session with any source, as long as controller is IR-authenticated. *(allow control only by most recent device to turn on TV)*

Instant Matchmaker as Security Mediator



Conclusions

- demonstrated approach for securely integrating personal and local ubiquitous computing resources
- introduced use of personal device as “instant matchmaker” to:
  - securely introduce new untrusted devices to user’s personal resources
  - provide reliable indication of what resources user wishes to access
- flexible approach to specifying fine-grained access control policy on the fly

A Few General Principles

(Everybody's got to have a set…)

- Implicit Security
  - if an explicit user request requires security changes to effect, don't make them ask again
    - » no separate but (un)equal security interface
    - » doesn't mean security must always be invisible, just that it ought to be when it can
- "And Nothing Else" Security Policy
  - easy and intuitive metric for what a system ought to do
- Who are the users?
  - usability also impacts developers, designers, administrators…
- User decisions should be framed in terms of application tasks
  - that is all that they care/know about
  - pushes security back up to the level of the application
- Users don't need to know and love your abstractions
  - "share the pain" not a good design mindset

Extra Slides

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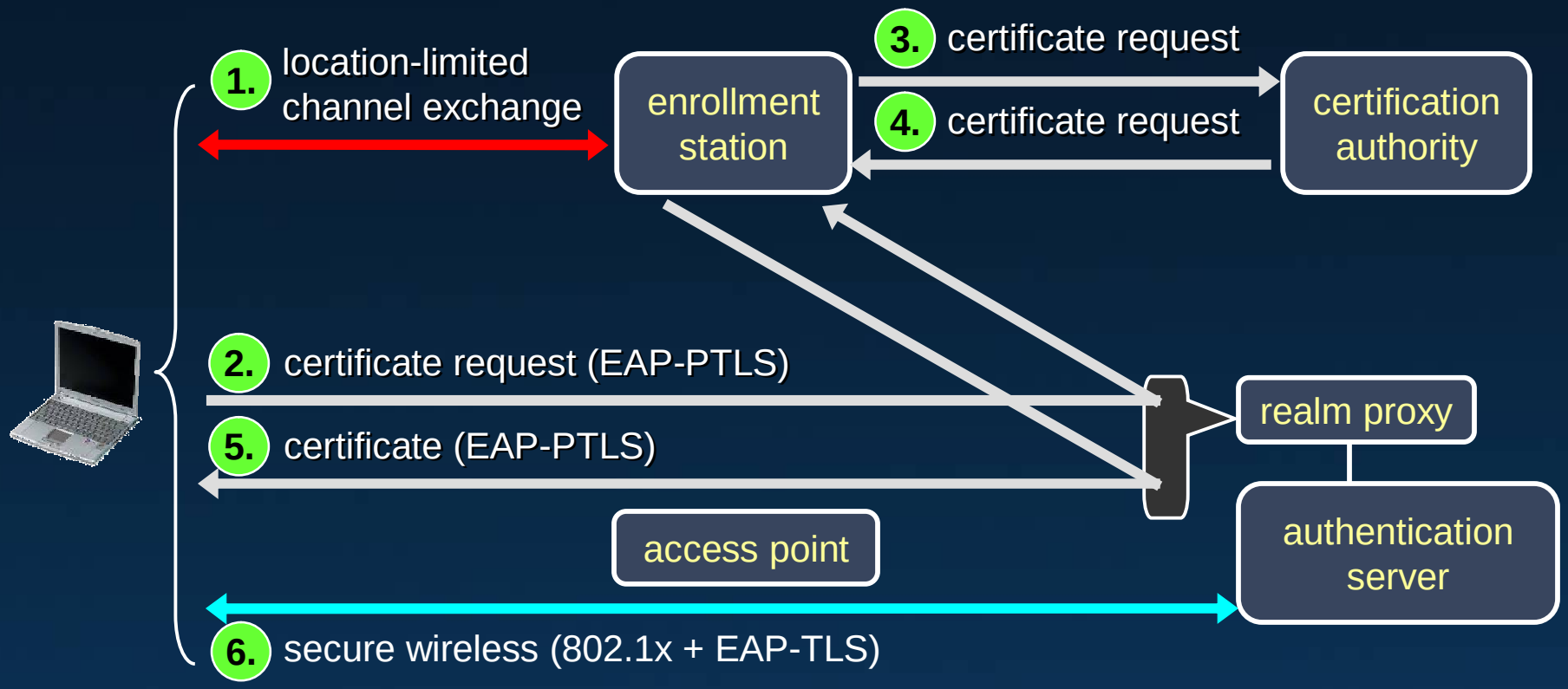
Other NiaB Features

- Network status monitoring and individual device revocation
  - simple web interface
  - see who is currently associated with the network
  - one-button revocation of any enrolled device
- “Phone Home” VPN service
  - enrolled device configured to enable easy VPN access back to their home NiaB
  - IPsec connection authenticated using same certificate as used to access wireless LAN
  - can be separately enabled/disabled from WLAN access

System Architecture



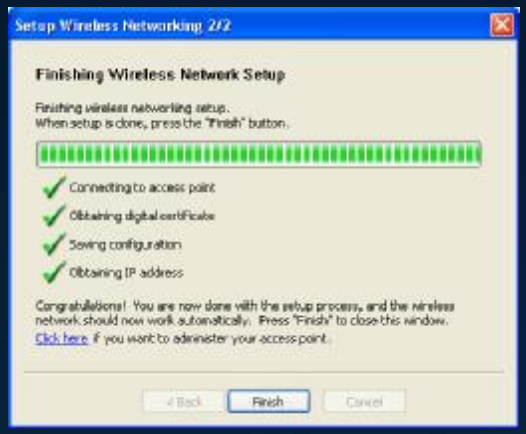
System Protocols

- EAP-PTLS: Client to Enrollment Station (EAP Traffic) (Trivial variant of EAP-TLS)
  - EAP-TLS performs standard TLS handshake then stops
  - We simply send messages inside the TLS tunnel
  - Endpoints use self-signed certificates
    - Hashes are compared against those received in location-limited channel
- CMP: Client to Enrollment Station (Certification Requests)
  - send PKCS#10 certification requests via Certificate Management Protocol (CMP, RFC 2510)
- Misc: Enrollment Station to Certification Authority
  - CA-specific protocols and transports

NiaB Implementation Details

- Lightweight implementation on commodity hardware, using mostly open source tools
- Implemented on standard Linux platform (RedHat 9.0, kernel 2.6)
  - Access Point: HostAP
  - Authentication Server: FreeRADIUS 1.0.0
  - Certification Authority
    - Small standalone CA using OpenSSL 0.9.7
    - Implemented as part of a FreeRADIUS plugin
  - Enrollment Station
    - Based on set of portable protocol libraries
    - Implemented as part of a FreeRADIUS plugin
  - VPN Server
    - Linux kernel 2.6 built-in IPsec
    - ipsec-tools' port of Racoon IKE daemon
  - Configuration Interface: mini_httpd
- Hardware platforms
  - OpenBrick modified to include front-access IR port
  - Linksys access point modified to support hardware IR

NiaB Client Implementation



- Primary Platform: Windows XP
  - Iterative design used to improve interface
  - Once client is configured, all further wireless network access done by native Windows XP 802.1x client – our software no longer used
- Basic implementations on other platforms (Linux, OS X)
  - all core libraries cross-platform

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User Experience

- We conducted usability tests to compare traditional PKI + 802.1x enrollment against Enterprise NiaB.
  - Results showed ours took less time, and fewer configuration steps

System	Time (min)	Steps
Traditional PKI	140:00	38
Enterprise NiaB	1:39	4

  - Users rated NiaB *(1 = most positive, 5 = most negative)*
    - easier to use
    - a more satisfying experience (satisfaction)
    - more confident that they configured security correctly (confidence)

System	Ease of Use	Satisfaction	Confidence
Traditional PKI	5	4	4
Enterprise NiaB	1	1	1

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