Newspeak: A Paradigm for Architectural Security

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We’re Doing Security Wrong

We’re Doing Security Wrong
What Has Changed?
War Stories
Analysis
A New Hope
Conclusions

- Traditional approaches haven’t worked well in the past
- They aren’t working now
- It is extremely unlikely that they will work in the future

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What Has Changed?

- We are much more reliant on (networked) computer systems
- Today's systems are much more complex (and hence probably have many more bugs)
- We have many more active enemies: cyberthieves, hacktivists, foreign governments, etc.
- The *threats* have changed, but the vulnerabilities are the same

War Stories

CardSystems Solutions

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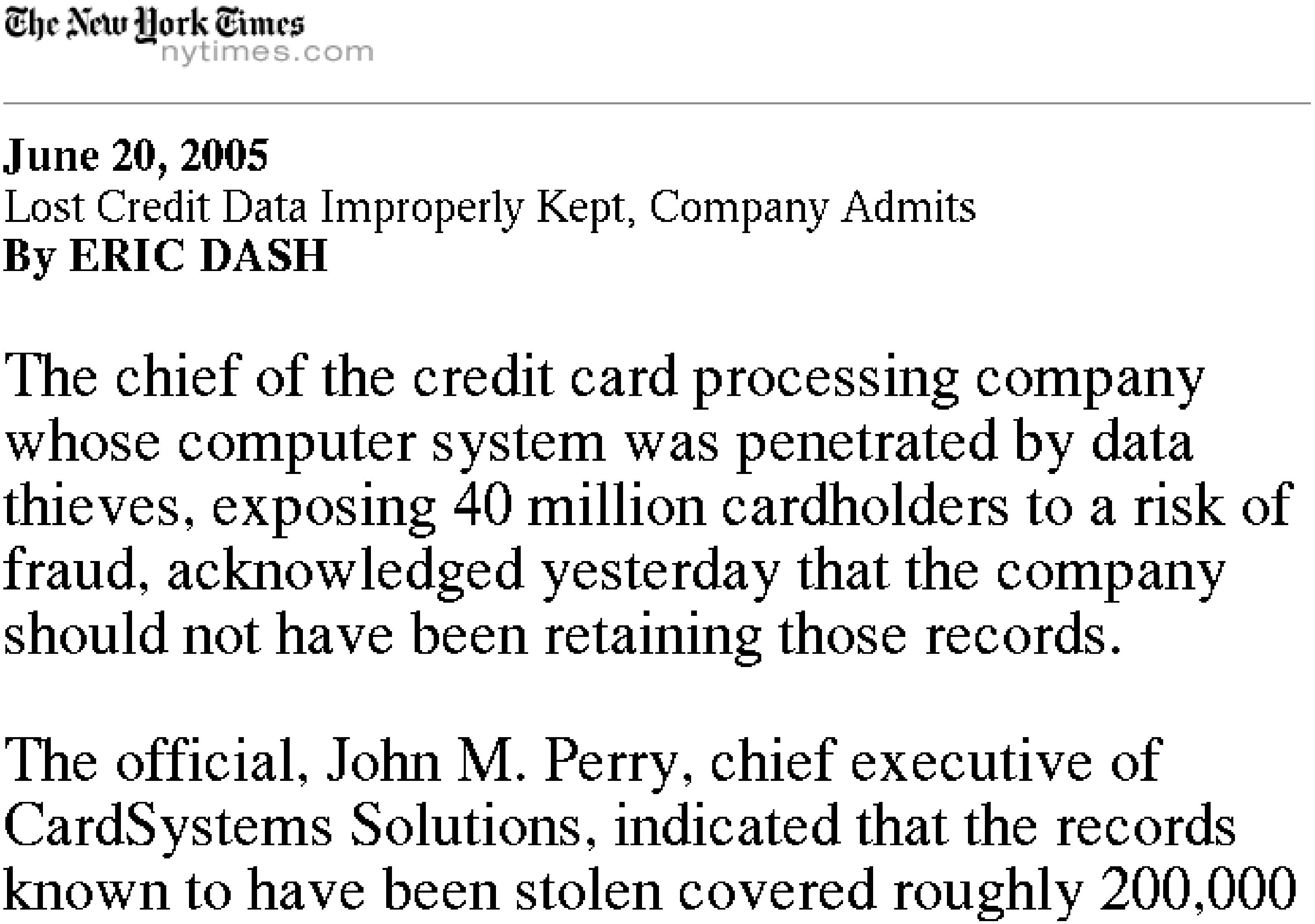
What Went Wrong?
Analysis
SQL Injection Attacks
Industry Response
TJX
Careless Networking, Clever Crooks
One More Horror Story
A Sophisticated Attack

Analysis

A New Hope

Conclusions



The New York Times
nytimes.com

June 20, 2005
Lost Credit Data Improperly Kept, Company Admits
By ERIC DASH

The chief of the credit card processing company whose computer system was penetrated by data thieves, exposing 40 million cardholders to a risk of fraud, acknowledged yesterday that the company should not have been retaining those records.

The official, John M. Perry, chief executive of CardSystems Solutions, indicated that the records known to have been stolen covered roughly 200,000

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What Went Wrong?

- Simple technical flaws!
- They had been audited:

> CardSystems underwent a Visa security audit in December 2003 and was certified by Visa in June 2004 as complying with Visa's security rules.

- At some point, the company misbehaved:

> CardSystems acknowledged it had stored . . . cardholder names, account numbers, and security codes in violation of both MasterCard's and Visa's rules.

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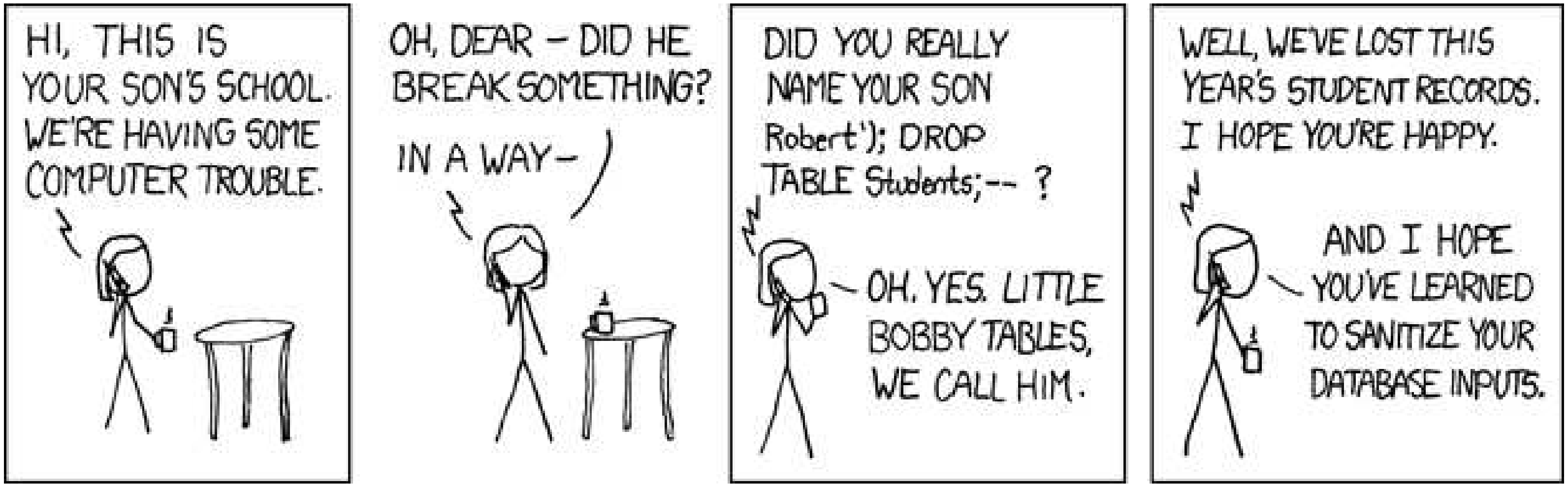
Analysis

- The audit didn't do its job
- It missed SQL injection attacks!
- There was misfeasance by the company
- Their (technical) defenses failed. (An inside job?)

SQL Injection Attacks

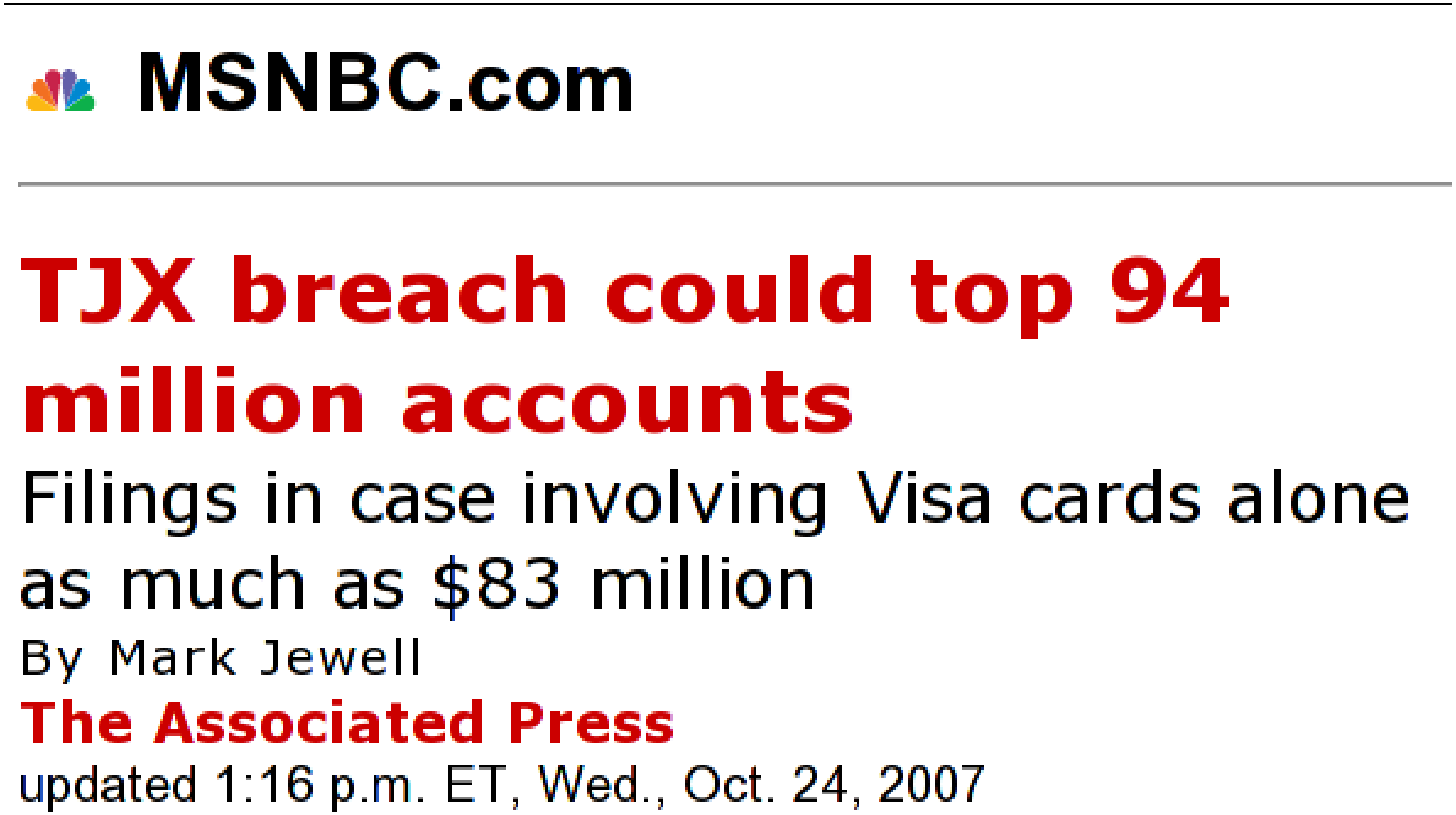

HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.
OH, DEAR – DID HE BREAK SOMETHING?
IN A WAY–
DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?
OH. YES. LITTLE BOBBY TABLES, WE CALL HIM.
WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.
AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

(From `http://xkcd.com/327/`)

Industry Response

- CardSystems Solutions was effectively put out of business by the credit card companies
- Technical standards were tightened
- Did it do any good?

TJX



MSNBC.com

TJX breach could top 94 million accounts

Filings in case involving Visa cards alone as much as $83 million

By Mark Jewell

The Associated Press

updated 1:16 p.m. ET, Wed., Oct. 24, 2007

Careless Networking, Clever Crooks

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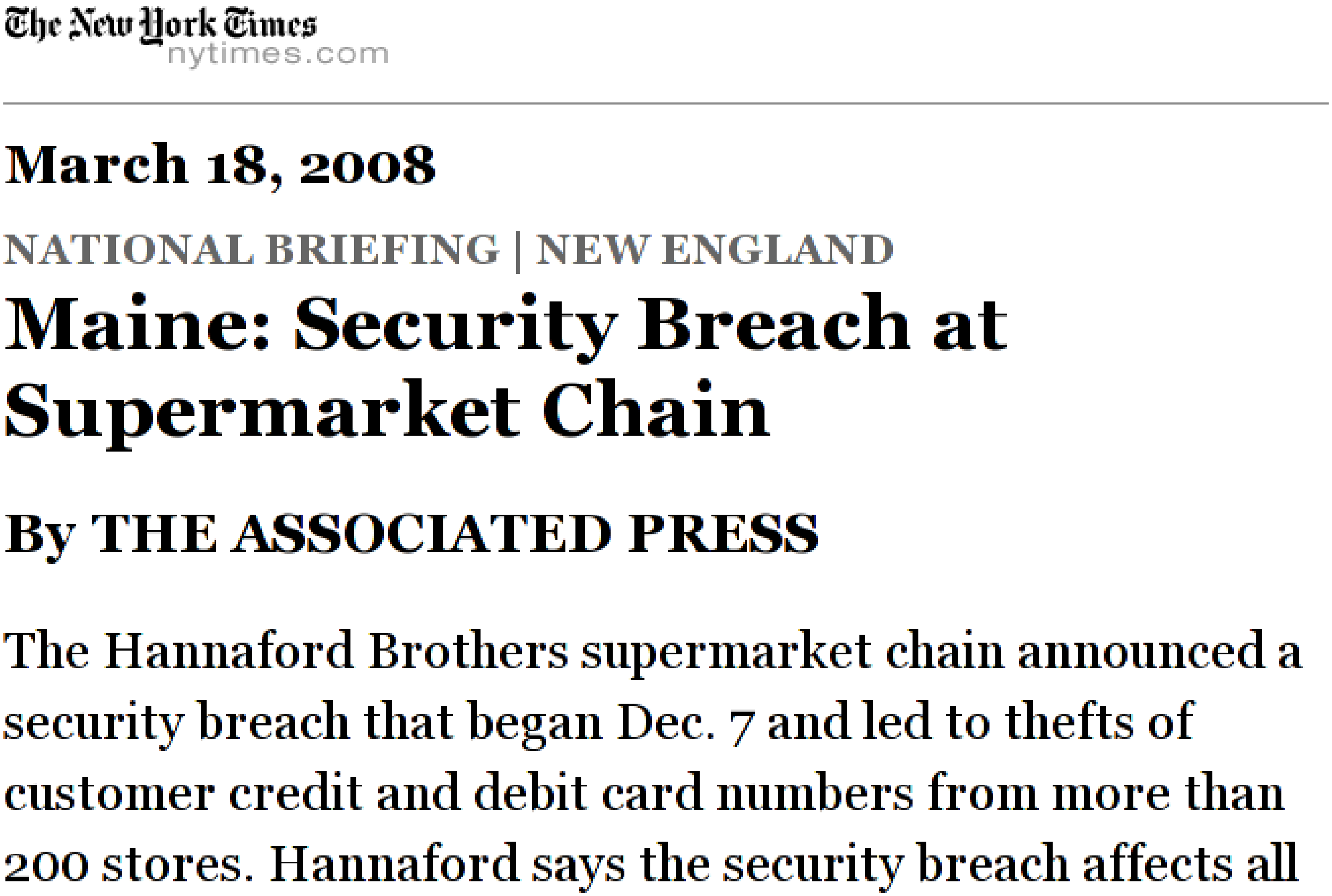
- TJX used 802.11 ("WiFi") with WEP, a known-weak technology

> TJX is of the view that the intruder initially gained access to the system via the wireless local area networks (WLANS) at two stores in the United States.

- At the time of the initial penetration, industry standards permitted WEP
- Personal data (i.e., driver's license numbers and social security numbers) was unnecessarily and improperly stored
- Losses to TJX approached $200M. . .

One More Horror Story



The New York Times
nytimes.com

March 18, 2008

NATIONAL BRIEFING | NEW ENGLAND

Maine: Security Breach at Supermarket Chain

By THE ASSOCIATED PRESS

The Hannaford Brothers supermarket chain announced a security breach that began Dec. 7 and led to thefts of customer credit and debit card numbers from more than 200 stores. Hannaford says the security breach affects all

A Sophisticated Attack

- Hannaford Bros. was fully compliant with all relevant standards
- The data was intercepted in transit over fiber optic networks
- How? Sniffing software was installed on hundreds of servers
- But — no end-to-end encryption

Analysis

Commonalities

- The companies involved were largely compliant with industry standards
- Industry standards lag the state of the art

> Wider use of encryption might seem an obvious answer. But in practice, encryption is unused at certain points in a data-processing chain because the computing power it requires can slow transactions.
>
> "Would you like to sit at your gas pump for five minutes to get an authorization?" said Avivah Litan, a security analyst at Gartner Inc.

The Data is the Target

- The attackers didn't care about the systems
- They wanted *data*
- They wanted *financially valuable* data

The Attackers Are Knowledgeable

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The Attackers Are Knowledgeable
Root Causes
Traditional Defenses
ASSERTIONS
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- They've attacked obscure industry segments
- They've penetrated uncommon software
- They've gone after bulk sources of data
- They've resold the stolen data to users

Root Causes

- Personnel misbehavior
- Insider attacks?
- Buggy code
- Poor encryption
- Encrypting the wrong thing

Traditional Defenses

- Background checks
  ⇒ Rarely done in the civilian sector
- "Evaluated" code (if we're lucky)
  ⇒ Misses many bugs — and most people use COTS systems
- Use good crypto
  ⇒ Most people can't evaluate the quality of crypto
- Firewalls
  ⇒ Often in the wrong place, and blocking the wrong things

ASSERTIONS

- This way lies madness
- We will *never* have bug-free code
- Complex systems will *always* have security bugs
- Almost no one can afford the time and people needed to do things properly
- We need a new approach

A New Hope

Design Principles

- Data-centric architecture, with strong protections around the important data
- Accept the inevitability of security holes
- Inherent resilience
- Inherent protection of *most* of the data

Classical Design

- Many applications, often less trusted
- Complex server application
- Back-end database(s) managed by the server application
- Firewalls protect the server

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Multiple Conversations
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Sample Configuration
The Hard Parts
Why It Works
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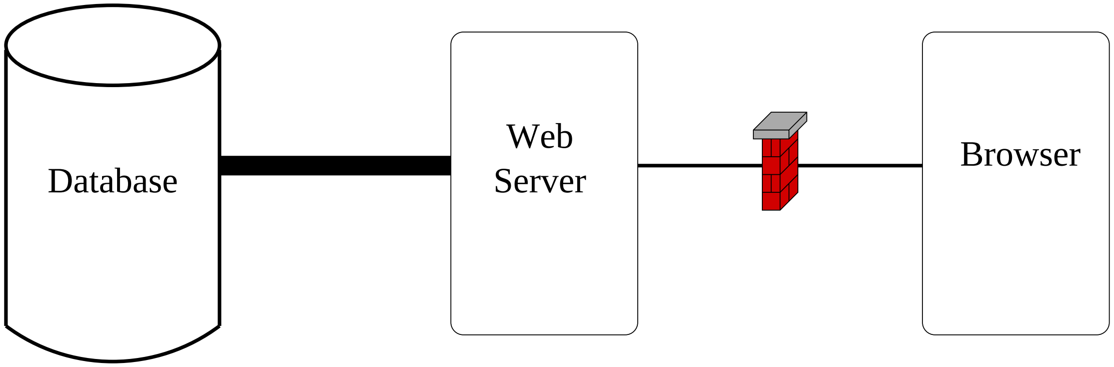
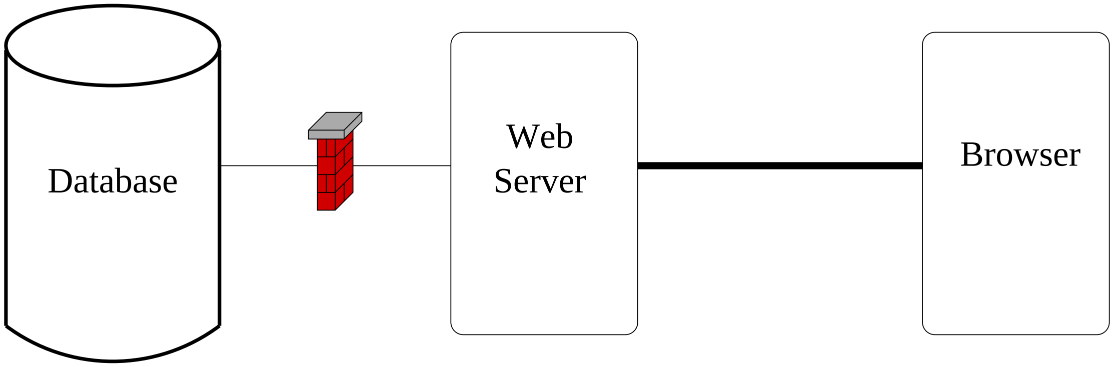
Wrong and Right

The Wrong Approach



The Right Approach



Why?

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- The firewall in the first case is pointless: the big risk comes from the web server
- If the web server falls, the database is completely exposed
- Or: expose the web server *machine*, turn off all other services, and protect the database

Data-Centric Approach

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- The web server is a syntax translator
- A *simple* language is used between the web server and the database
- Encryption and authentication are from the end user to the database
- Syntax-directed checking of database inputs

Newspeak

"The purpose of Newspeak was not only to provide a medium of expression for the [proper] world-view . . . but to make all other modes of thought impossible.

. . .

"There would be many crimes and errors which it would be beyond [a person's] power to commit, simply because they were nameless and therefore unimaginable."

1984, George Orwell

Newspeak 2.0

- No SQL injection — because SQL is only invoked on sanitize inputs
- No verb to dump the database
- No verb to read a credit card number
- The web server can only operate on accounts selected by end users

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What if the Web Server is Compromised?

- Even without end-to-end encryption, only active accounts are at risk
- Most accounts aren't active most of the time
- Use an IDS to detect web server compromise

Multiple Conversations

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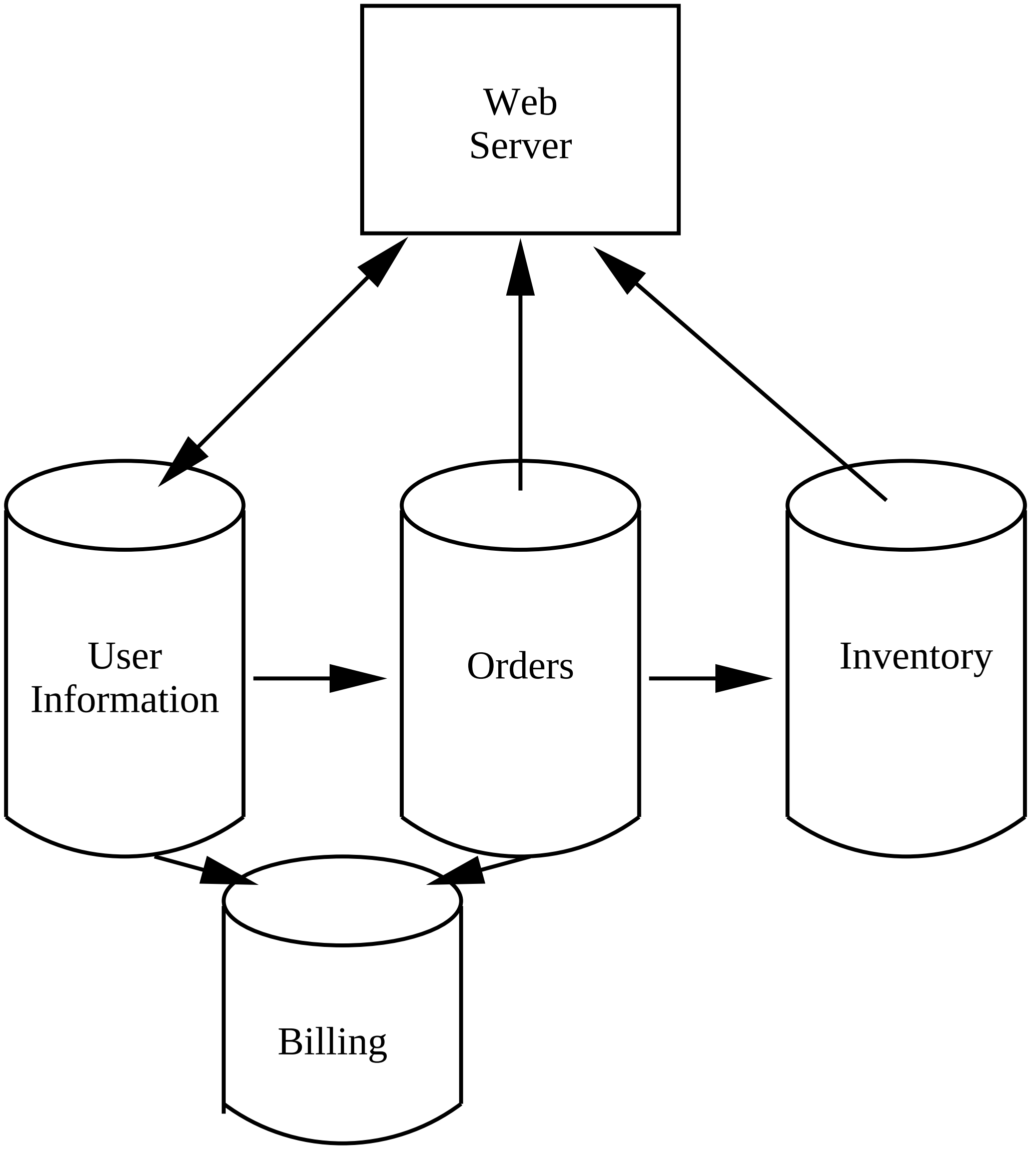

Arrows show direction of information flow

Data Flow

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- The *user object* places an order
- Credit card numbers are sent *only* to the billing system
- The *order object* supplies the total price
- It also updates the inventory
- *The web server can do very little*

A Prototype: Propylaeum

- The web server sends Javascript encryption code to the web browser
- All data is encrypted to the Propylaeum daemon
- It decrypts, authenticates, and *filters* the data
- A simple configuration file describes each data syntax via regular expressions
- Neither the web server nor the database server handle untrusted data

Sample Configuration

```
<?xml version="1.0" ?>
<propylaeum>

<variables>
<allowed-value varname="ISBN" regex="[0-9-]">
<allowed-value varname="NAME" regex="[A-Za-z0-9-]">
<allowed-value varname="CC" regex="[0-9 ]">
</variables>

<action name="BOOK_DETAIL">
<query>
SELECT ISBN, TITLE, AUTHOR, IMAGEURL FROM CATALOG
    WHERE ISBN = ’[[ISBN]]’
</query>
</action>
```

The Hard Parts

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- Minor issue: public key encryption in Javascript is slow (and no one implements shttp)
- Major issue: designing the dialect(s) of Newspeak
- Every application is different; middleware layers tend to be too powerful

Why It Works

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- The complex logic isn't trusted — it's outside of the TCB
- The database isn't exposed to untrusted, unfiltered inputs
- The filter daemon is small enough that (perhaps) we can get it right

Conclusions

Looking Back at Tradition

- Designs of the past were host-centric
- The OS was relied on to mediate all data transfer
- Security strength was measure by ACL power
- The network was a glorified form of remote login
- None of that is true today

Today's Environment

- Network-centric
- Server computers run one application, in one protection domain
- We have no network-wide reference monitor
- Any such monitor has to be application-specific

Conclusions

- Newspeak isn't the only possible solution
- But — any robust solution will need to follow some of the same principles
- Modern TCBs are at the *application level*
- The OS has a secondary role; at best, it can provide strong isolation between components
- The danger points are the communications channels; those need to be strongly protected *against bugs*