

Failure Analysis of the PSTN: *2000*



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Approach

- Find the areas that are failing then try to fix/address the problems
- Use PSTN as a case study for ROC:
 - Large, widely used, networked system
 - Highly reliable infrastructure
 - Provides an upper limit for reliable computer service
- **Ideal:** Computers be as reliable as the telephone network.

BEST CASE



Collecting Failure Data

➤ Target System:

US **P**ublic **S**witched **T**elephone **N**etwork (PSTN)

➤ Detailed telephone service failure data available from the **F**ederal **C**ommunications **C**ommission (**FCC**)

➤ Telephone Disruption reports: company name, duration, time, cause, and event disruption

➤ Required by law for outages affecting 30,000 people or lasting at least 30 minutes

Outage Report

WIRE LINE OUTAGE REPORTING TEMPLATE

Company

Date

Box #1: Reporting Carrier
AT&T

Final

Box #2: Date of Incident (mm/dd/yy)
2/5/2001

Box #3: Time of Incident (at outage location; 24-hour clock)
15:47 EST

Box #4: Geographic Area Affected
Orlando, FL

Time

Box #7: Services Affected

Box #5: Number of Customers Affected
Apprx. 777,652

IntraLATA Intraoffice

IntraLATA Interoffice

InterLATA Interoffice

E911

Box #6: Number of Blocked Calls
2,332,957

Other (specify): International, Intertoll,
toll access, toll completing & NCP based

Box #8: Outage Duration
Hrs. 6 Min. 53

Number of
Customers
Affected

Blocked
Calls

Duration

Box #9: Background of the Incident

Jones Brothers Contracting was installing a new sewer line as part of a Department of Transportation (DOT) project. This project has been on-going for approximately two years. In the course of two years the AT&T technician has worked with this contractor on several occasions where they have crossed the AT&T fiber cable. Although the cable had been marked, the contractor took it upon himself to expose the cable by potholing without notifying the AT&T Technician. The contractor then resumed digging with the trackhoe and severed the AT&T cable.

Explanation

Box # 10: Direct Cause
Cable Damage

Cause

Box #11: Root Cause
Cable Damage - Digging Error

Causes of Failure

- Human Error
- Acts of Nature
- Hardware Failure
- Software Failure
- Call overloads
- Vandalism





Categorizing the Failures

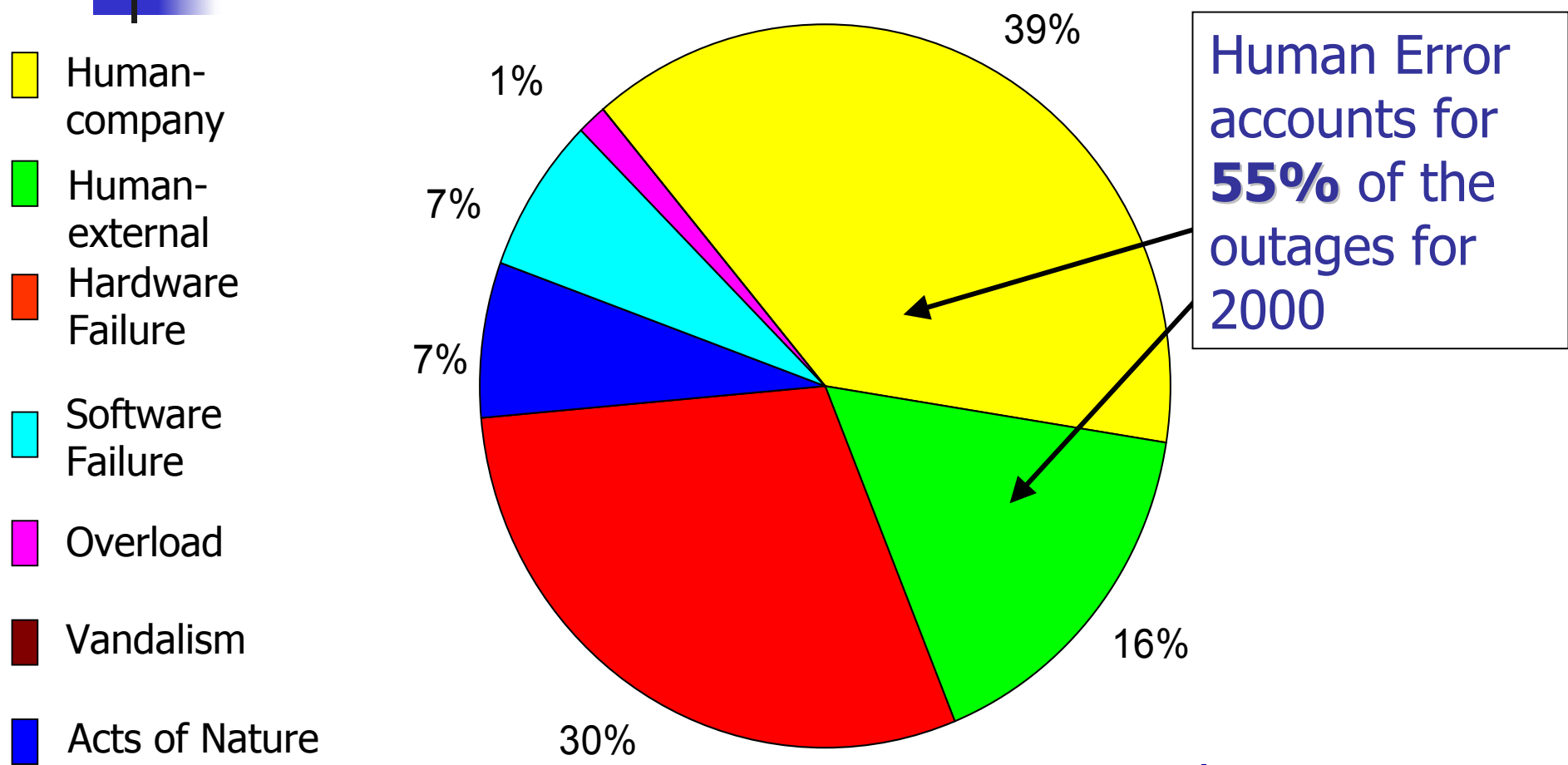
- Human Error
 - Company workers
 - Includes Contractors and Vendors
 - External
- Acts of Nature
 - Fire
 - Rain
 - Lightning
 - Winds
 - Floods
- Hardware Failure
 - Network component failure
 - Cable, power outage
- Software Failure
 - corrupt/incorrect communication software
- Call Overloads
 - Over network capacity
- Vandalism
 - Intentional harm to telephone network equipment



Categorization Challenges

- Outages may have **multiple** causes
- Terminology
 - **Root Cause** - cause behind the outage
 - **Direct Cause** - immediate trigger
- i.e.
 - Root Cause – latent error in software
 - Direct Cause – Maintenance error (human)

Outages Breakdown by Number:



Human Error accounts for **55%** of the outages for 2000

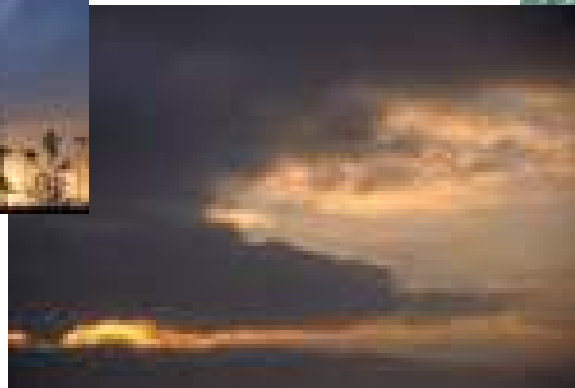
Total: 202 outages

*Vandalism accounts for < 1%

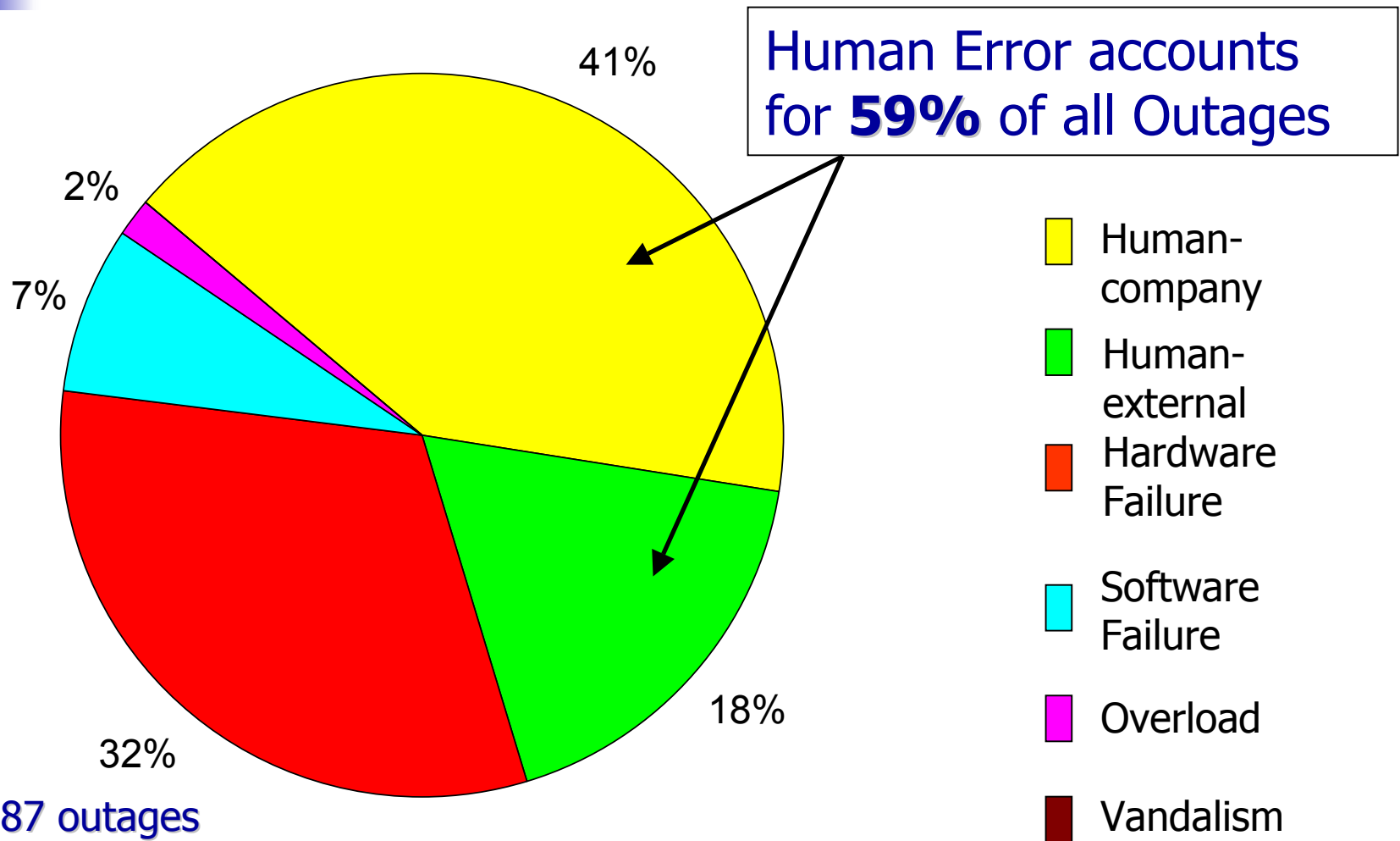


Eliminating Nature

- Nature has a mind of its own
 - Cannot be controlled
- Does not relate to contained computer systems directly



Outage Breakdown by Number (Nature Factored Out)





What could humans possibly do wrong?

- Cut incorrect cables
- Upgrade software incorrectly
- Incorrectly repair hardware
- Follow instructions incorrectly
- Fail to read documentation
- Do things out of order



Measuring Availability

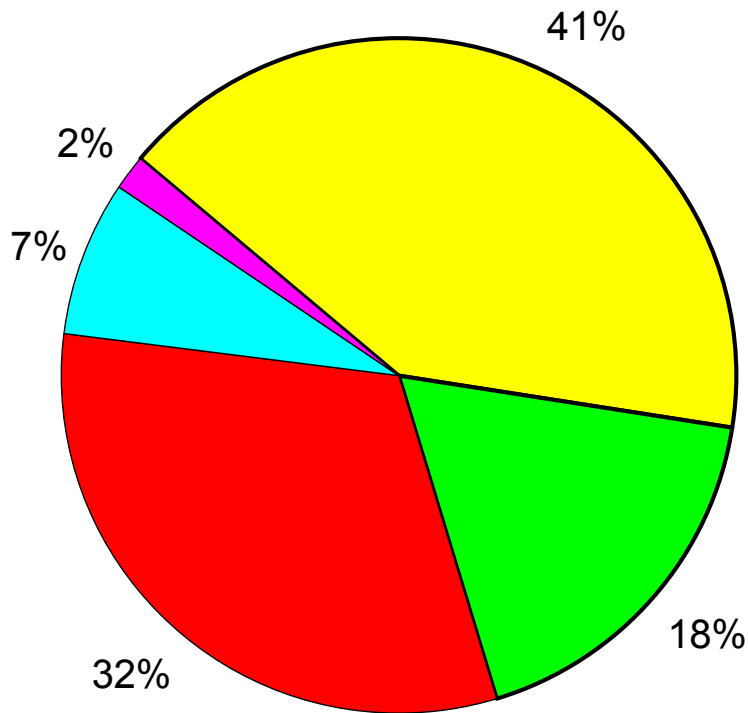
- Number of Outages
 - Only measures the number of outages.
 - Does not include the duration of the outages.
 - There's more important information than simply the number of outages.
 - Outage Duration
 - Customers Affected
 - Blocked Calls



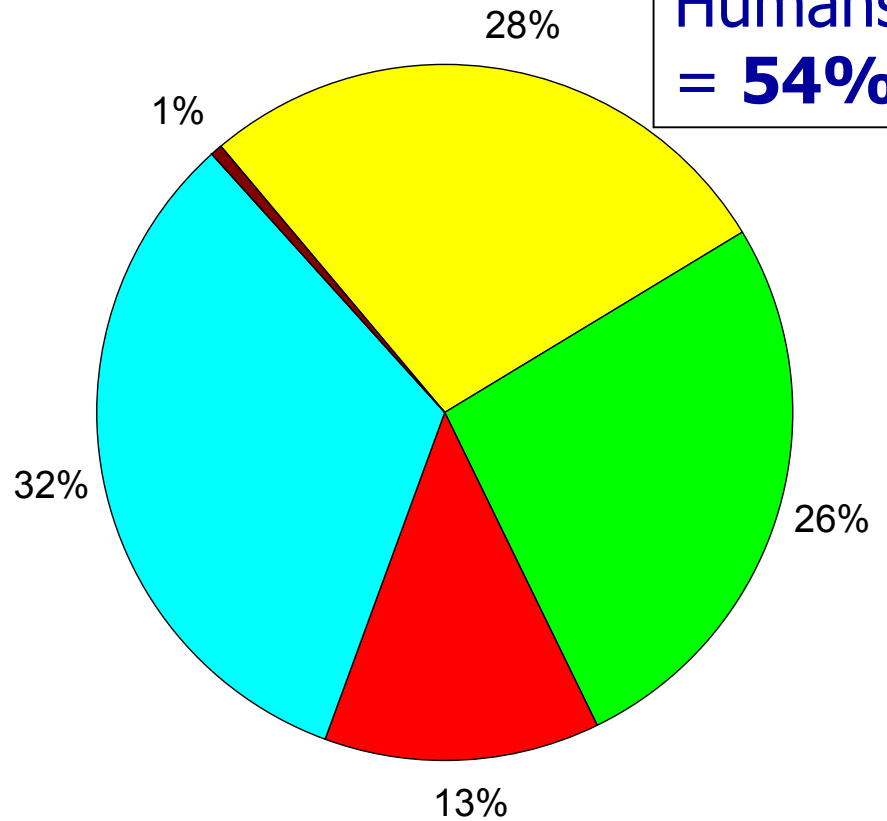
A Second Metric

- **Customer Minutes**
 - Outage duration in Minutes * Customers affected
 - Captures collective customer experience
 - Assumes all affected customers or lines attempted to make a call

Number of Outages vs. Customer Minutes



Total: 187 outages



**Total: about 95 Million
customer minutes/year**

**Humans
= 54%**

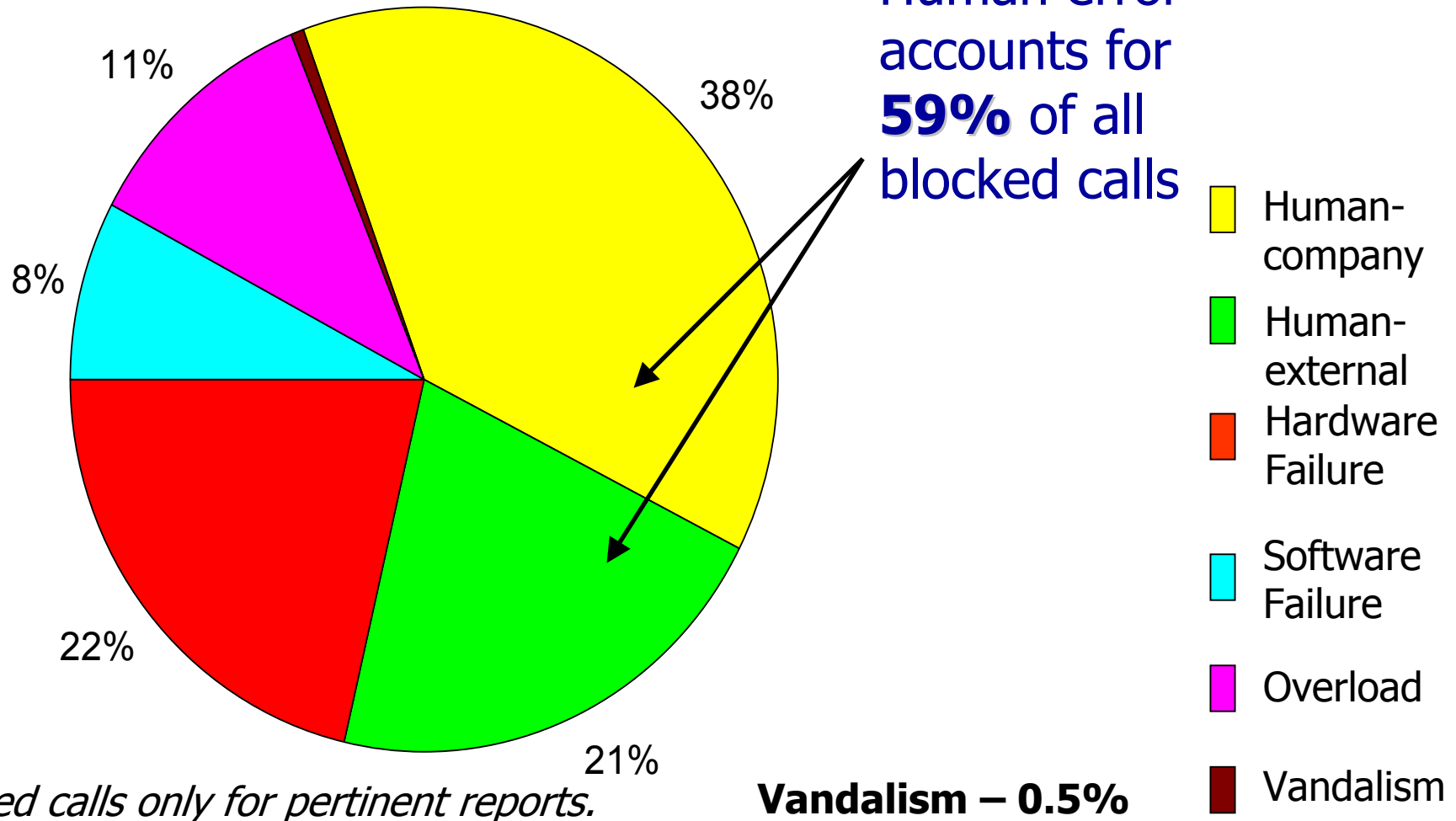


A Better Metric

- **Blocked calls**

- Number of calls that are interrupted during a service disruption.
 - Exact values or Estimated values
- Reported by the company on the disruption report.
- Measures how many “service items” or calls were interrupted.
 - Does not assume customer use as do customer minutes.

Blocked Calls: 2000





Summary:

- Humans were the greatest cause of failure.
 - Humans caused most of the outages.
- What are the trends?
 - 1997- Richard Kuhn reported on the failure in the phone system for 1992-1994
(Sources of Failure in the Public Switched Telephone Network)
 - Also found humans to be the biggest problem

Trends in Customer Minutes

Cause	Trend	Minutes (millions of customer minutes/month)	
		1992-1994	2000
Human Error: Company	↑	98	131
Human Error: external	↑	100	125
Hardware	↑	49	60
Software	↑	15	155
Overload	↓	314	2
Vandalism	↓	5	2

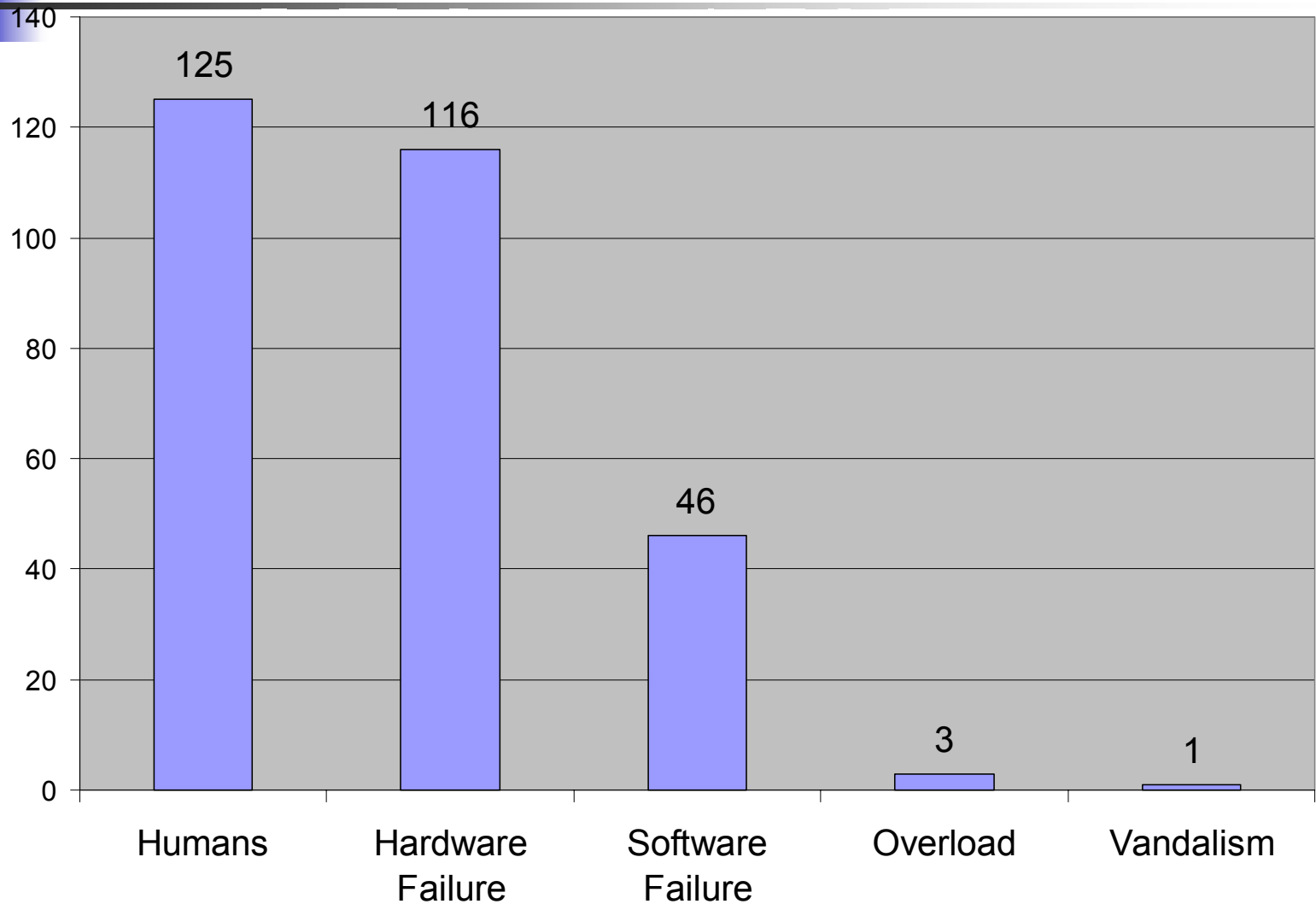
“Traditional Computing concentrates on tolerating hardware and operating system faults, ignoring faults by human operators...” (David Patterson, 2001)



A New Perspective

- Outages may be caused by multiple components
 - Combinations of a few or several
- Each component plays a key role in the outage coming about.

Components Of Failure





Future Work:

- Directly apply data to the ROC project
 - Could the ROC techniques have avoided these outages?
- Further categorize the data
 - More specific categories within each general category
 - Telephone Company
 - Geographic location
 - Breakdown Human error further
 - Vendors, contractors, technicians, outsiders...
- Include more years of outages for further comparison



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