# A Note on the Confinement Problem

*How* to prepare a sample talk

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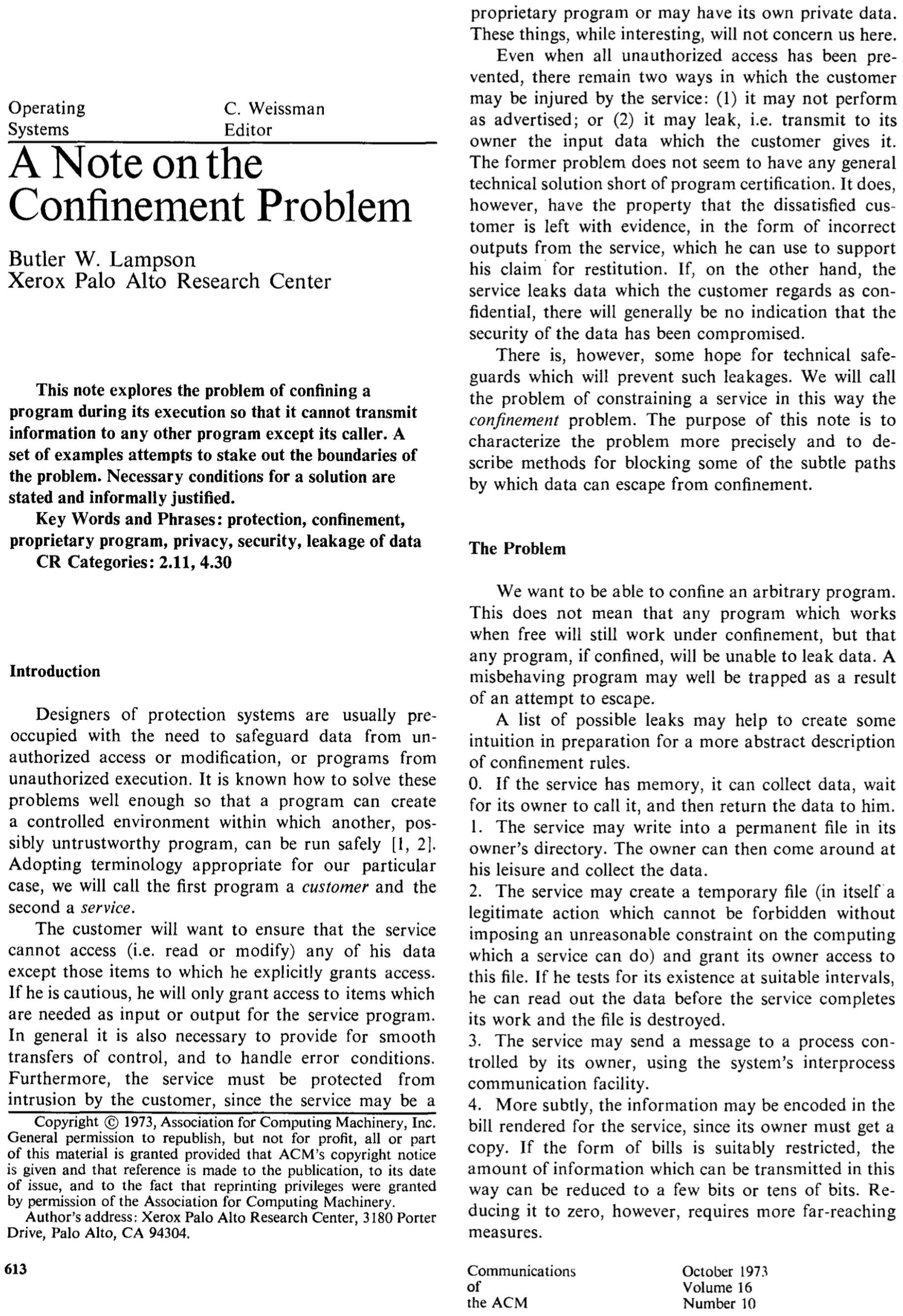

Operating Systems

C. Weissman Editor

# A Note on the Confinement Problem

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This note explores the problem of confining a program during its execution so that it cannot transmit information to any other program except its caller. A set of examples attempts to stake out the boundaries of the problem. Necessary conditions for a solution are stated and informally justified.

Key Words and Phrases: protection, confinement, proprietary program, privacy, security, leakage of data

CR Categories: 2.11, 4.30

## Introduction

Designers of protection systems are usually preoccupied with the need to safeguard data from unauthorized access or modification, or programs from unauthorized execution. It is known how to solve these problems well enough so that a program can create a controlled environment within which another, possibly untrustworthy program, can be run safely [1, 2]. Adopting terminology appropriate for our particular case, we will call the first program a *customer* and the second a *service*.

The customer will want to ensure that the service cannot access (i.e. read or modify) any of his data except those items to which he explicitly grants access. If he is cautious, he will only grant access to items which are needed as input or output for the service program. In general it is also necessary to provide for smooth transfers of control, and to handle error conditions. Furthermore, the service must be protected from intrusion by the customer, since the service may be a proprietary program or may have its own private data. These things, while interesting, will not concern us here.

Even when all unauthorized access has been prevented, there remain two ways in which the customer may be injured by the service: (1) it may not perform as advertised; or (2) it may leak, i.e. transmit to its owner the input data which the customer gives it. The former problem does not seem to have any general technical solution short of program certification. It does, however, have the property that the dissatisfied customer is left with evidence, in the form of incorrect outputs from the service, which he can use to support his claim for restitution. If, on the other hand, the service leaks data which the customer regards as confidential, there will generally be no indication that the security of the data has been compromised.

There is, however, some hope for technical safeguards which will prevent such leakages. We will call the problem of constraining a service in this way the *confinement* problem. The purpose of this note is to characterize the problem more precisely and to describe methods for blocking some of the subtle paths by which data can escape from confinement.

## The Problem

We want to be able to confine an arbitrary program. This does not mean that any program which works when free will still work under confinement, but that any program, if confined, will be unable to leak data. A misbehaving program may well be trapped as a result of an attempt to escape.

A list of possible leaks may help to create some intuition in preparation for a more abstract description of confinement rules.

0. If the service has memory, it can collect data, wait for its owner to call it, and then return the data to him.
1. The service may write into a permanent file in its owner's directory. The owner can then come around at his leisure and collect the data.
2. The service may create a temporary file (in itself a legitimate action which cannot be forbidden without imposing an unreasonable constraint on the computing which a service can do) and grant its owner access to this file. If he tests for its existence at suitable intervals, he can read out the data before the service completes its work and the file is destroyed.
3. The service may send a message to a process controlled by its owner, using the system's interprocess communication facility.
4. More subtly, the information may be encoded in the bill rendered for the service, since its owner must get a copy. If the form of bills is suitably restricted, the amount of information which can be transmitted in this way can be reduced to a few bits or tens of bits. Reducing it to zero, however, requires more far-reaching measures.

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The paper introduces a data security challenge

How were these framed?

# The confinement problem

*“The customer will want to ensure that the service cannot access (i.e. read or modify) any of his data except those items to which he explicitly grants access”*

# Context: computing in the 1970s…

# Concern was about leaking confidential data, not correctness

Can you remember the seven ways of leaking data?

# Concern was about leaking confidential data, not correctness

0. Leak via shared memory
1. Write data to a permanent file
2. Write data to a temporary file
3. Send data via IPC
4. Encode data in the bill for service
5. Encode data through write-locks on files
6. Artificially modulate system resource usage

# Proposed sol$^{n}$: use confinement to block explicit sharing

Three properties suggested:

- A confined program must be *memoryless*
- A confined program must make no calls to any other (unconfined) program
- A trustworthy supervisor

What does a trustworthy supervisor need to do?

# Side channels and covert channels are described

*“Examples 5 and 6 show that it is hard to write a trustworthy supervisor, since some of the paths by which information can leak out from a supervisor are quite subtle and obscure.* ***The remainder of this note argues that it is possible*** *… It is necessary to enumerate them all and then block each one”*

# The structure and content of a paper and a talk may differ

Paper structure

- Introduction
- The Problem
- Confinement Rules
- Summary

You don’t need to explain all the detail: focus on the important ideas

# What doesn’t the paper talk about?

# What doesn’t the paper talk about?

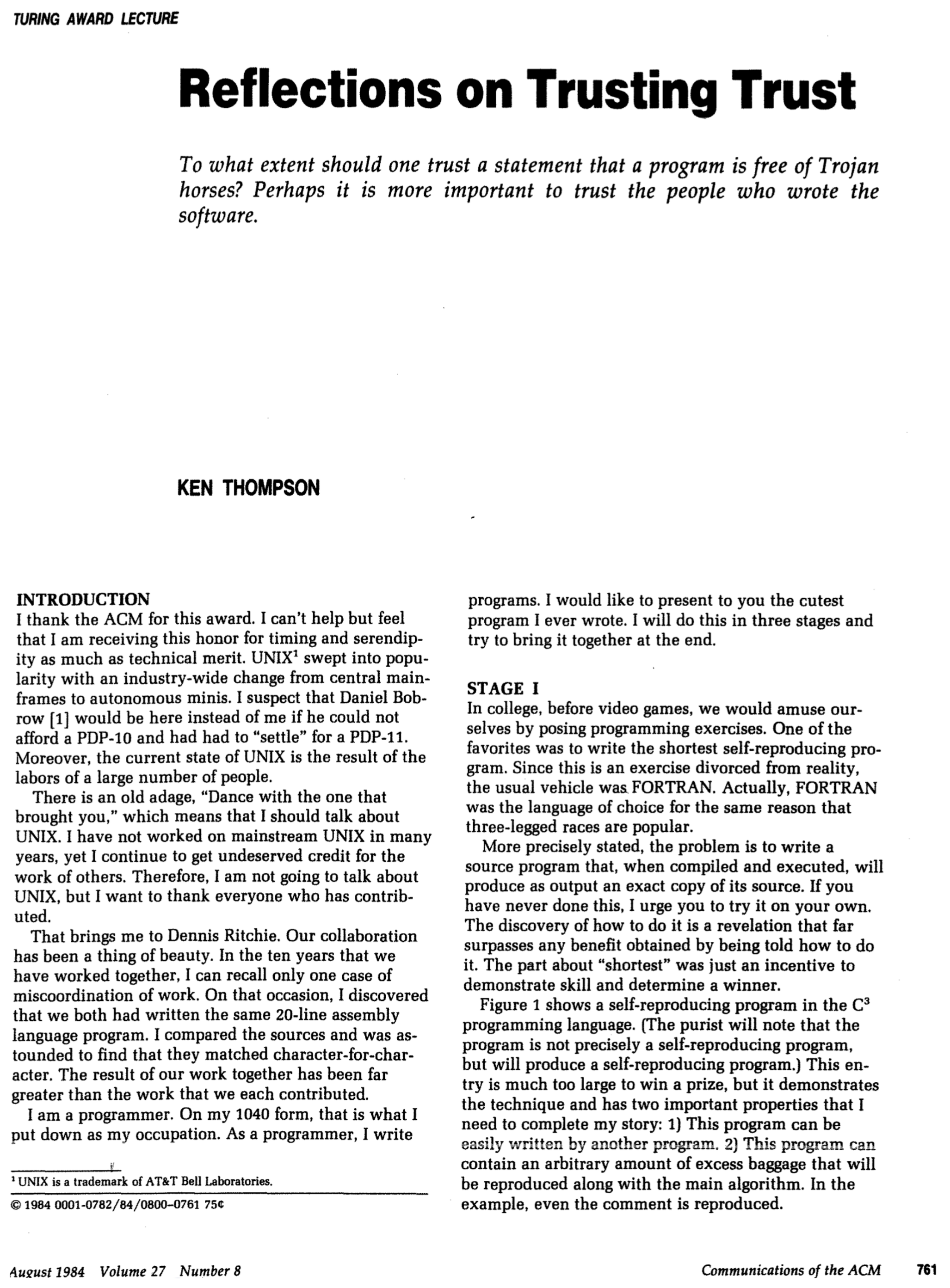
- Programming-language security
- Attacker models
- Cryptography
- Computer networking
- Anonymous users
- Mobile and cyber-physical systems

# Was the work novel at the time?

- Lampson, B.W. Dynamic protection structures. Proc. AFIPS 1969 FJCC, Vol. 35, AFIPS Press, pp.27-38.
- Schroeder, M.D., and Saltzer, J.H. A Hardware Architecture for implementing protection rings. Comm. ACM 15,3 (Mar. 1972), 157-170.

# Possible talk structure

| | |
|---|---|
| • Historical context: who, what, why? | 1 min |
| • Interpreting and explaining terminology | 2 |
| • Ideas found in the paper | 7 |
|     • The overall challenge | |
|     • Ways data might leak | |
|     • Confinement | |
| • Under explored ideas present at the time | 2 |
| • Papers cited and other ideas at the time | 1 |
| • Changes which have occurred since publication | 2 |
| • In what ways is the work (in)valid today? | 2 |
| (*total:* | 17 mins) |



# Reflections on Trusting Trust

*To what extent should one trust a statement that a program is free of Trojan horses? Perhaps it is more important to trust the people who wrote the software.*

KEN THOMPSON

## INTRODUCTION

I thank the ACM for this award. I can't help but feel that I am receiving this honor for timing and serendipity as much as technical merit. UNIX[1] swept into popularity with an industry-wide change from central mainframes to autonomous minis. I suspect that Daniel Bobrow [1] would be here instead of me if he could not afford a PDP-10 and had had to "settle" for a PDP-11. Moreover, the current state of UNIX is the result of the labors of a large number of people.

There is an old adage, "Dance with the one that brought you," which means that I should talk about UNIX. I have not worked on mainstream UNIX in many years, yet I continue to get undeserved credit for the work of others. Therefore, I am not going to talk about UNIX, but I want to thank everyone who has contributed.

That brings me to Dennis Ritchie. Our collaboration has been a thing of beauty. In the ten years that we have worked together, I can recall only one case of miscoordination of work. On that occasion, I discovered that we both had written the same 20-line assembly language program. I compared the sources and was astounded to find that they matched character-for-character. The result of our work together has been far greater than the work that we each contributed.

I am a programmer. On my 1040 form, that is what I put down as my occupation. As a programmer, I write programs. I would like to present to you the cutest program I ever wrote. I will do this in three stages and try to bring it together at the end.

## STAGE I

In college, before video games, we would amuse ourselves by posing programming exercises. One of the favorites was to write the shortest self-reproducing program. Since this is an exercise divorced from reality, the usual vehicle was FORTRAN. Actually, FORTRAN was the language of choice for the same reason that three-legged races are popular.

More precisely stated, the problem is to write a source program that, when compiled and executed, will produce as output an exact copy of its source. If you have never done this, I urge you to try it on your own. The discovery of how to do it is a revelation that far surpasses any benefit obtained by being told how to do it. The part about "shortest" was just an incentive to demonstrate skill and determine a winner.

Figure 1 shows a self-reproducing program in the C[3] programming language. (The purist will note that the program is not precisely a self-reproducing program, but will produce a self-reproducing program.) This entry is much too large to win a prize, but it demonstrates the technique and has two important properties that I need to complete my story: 1) This program can be easily written by another program. 2) This program can contain an arbitrary amount of excess baggage that will be reproduced along with the main algorithm. In the example, even the comment is reproduced.

[1] UNIX is a trademark of AT&T Bell Laboratories.

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What were the most interesting ideas in this paper?