# 6.S081 : VM for user applications

OS kernel use VM in creative ways

Paper argues user apps can use VM too

- Garbage collector
- Data compression
- SVM

## What primitives?

- Trap → alarm handler
  → sigaction
- mprotect
  - Prot1 — decrease accessibility
    R+W → R → not access
  - ProtN — save TLB flushes
  - Unprot — increase accessibility
- ? Dirty
- ? Map2 — several mmaps

__Unix today.__ mmap

map a file

addr = mmap(null, len, R/W, MAP_PRIVATE, fd, offset)

Next lab

map anonymous

# Unix today

mprotect ( addr, len, R ) → lds
NONE

→ sigalarm

unmap : remove address range

sigaction: signal handler (f)

signal: segfault.

## VM implementation

AS : page table + Virtual Memory Area (VMAs)

$\hookrightarrow$ Contiguous range of addresses
same permission
backed by same object

1000–2000

2100–2200

## User-level traps

PTE marked invalid / RO

- CPU jumps in kernel

Kernel save state

ASKs the VM system what to do? VMAs

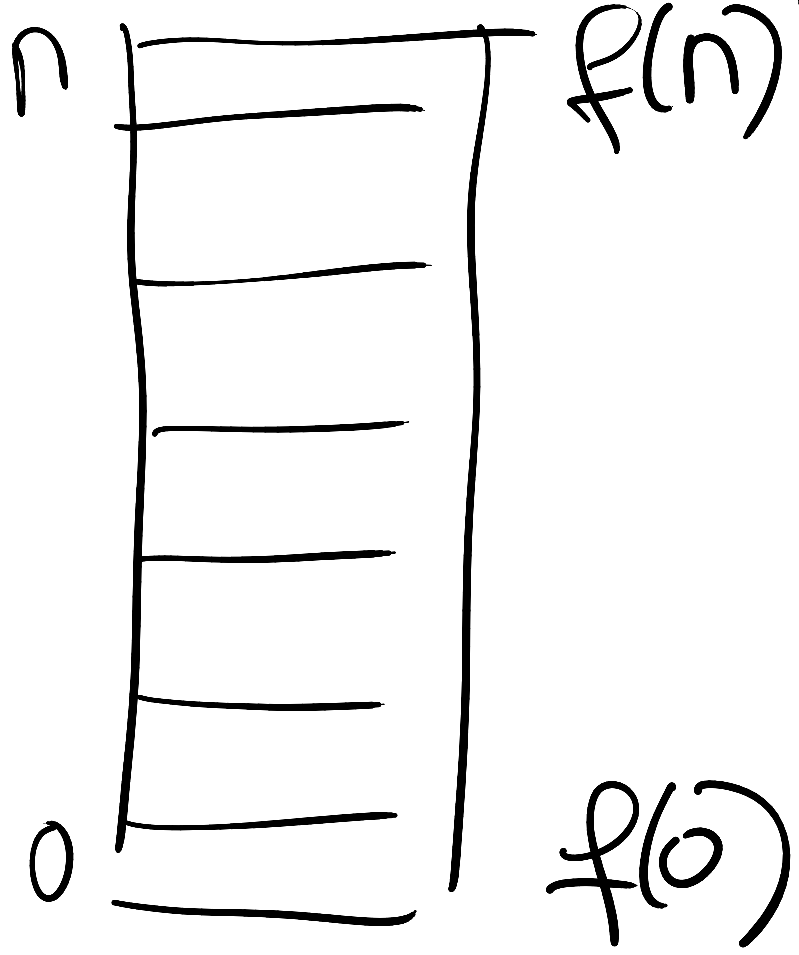
→ Upcall into user space

Run handler → mprotect()?

Handler returns to kernel

Kernel resumes interrupted process

## Example: Huge memoization table



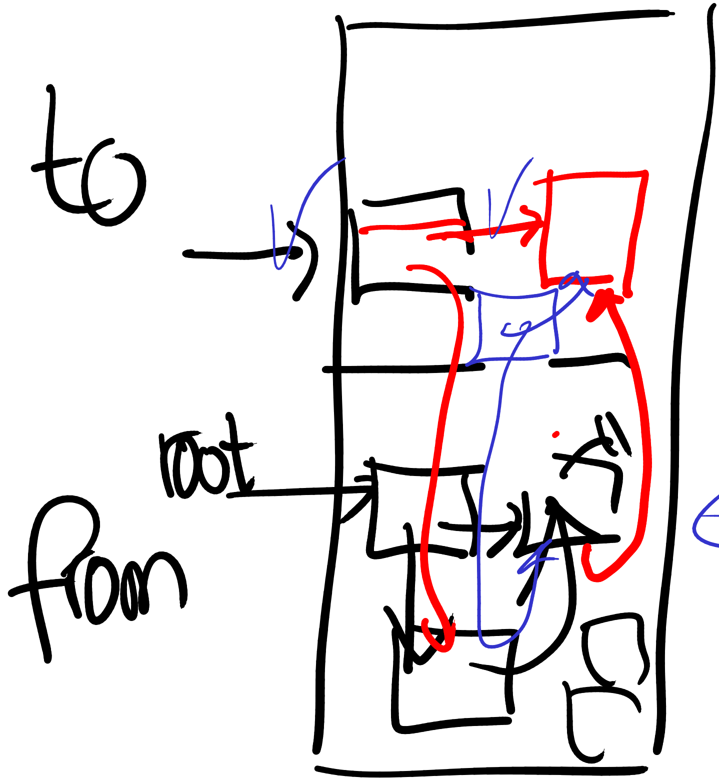
$f(i)? \rightarrow$ lookup $tb[i]$

<u>Challenge</u>: table might be big
> phys memory

<u>Sol</u>: use VM primitives
- allocate huge range
- $tb[i] \to$ pgfault $\to$ f(i) $\to$ tb[i]
  allocate page
- if much memory is in use, free some pages
  prot1/protN

## Example: garbage collector

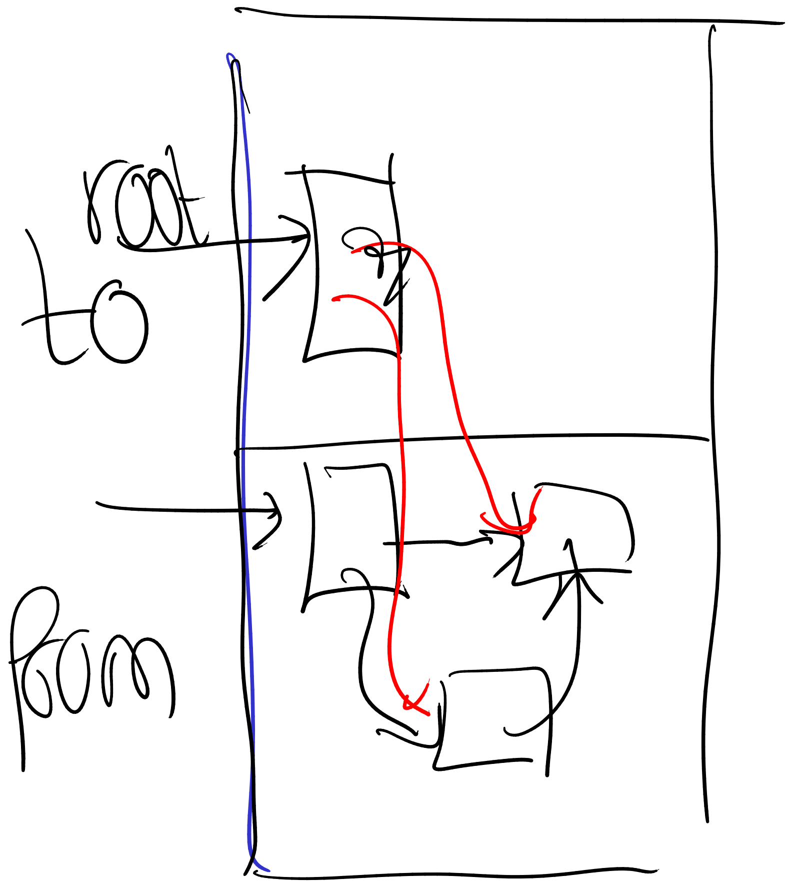
A copying garbage collector



forwarding

discarded ⇒ is now free space

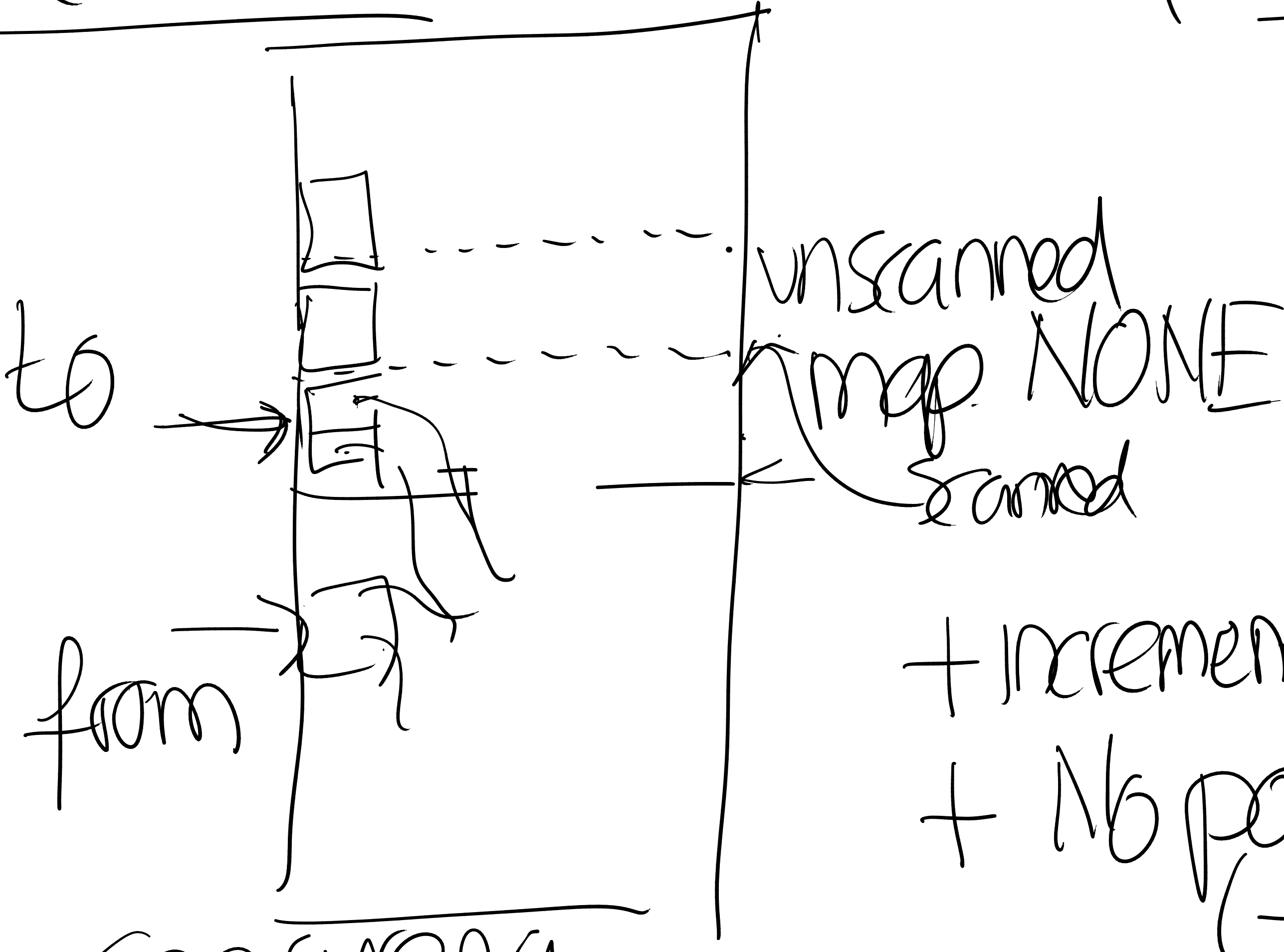
# Baker's: real-time ← incremental gc



new: forward a few more objects

dereference a pointer: check if in from space ⟹ forwarding

## Use VM:



concurreny

## fault handler

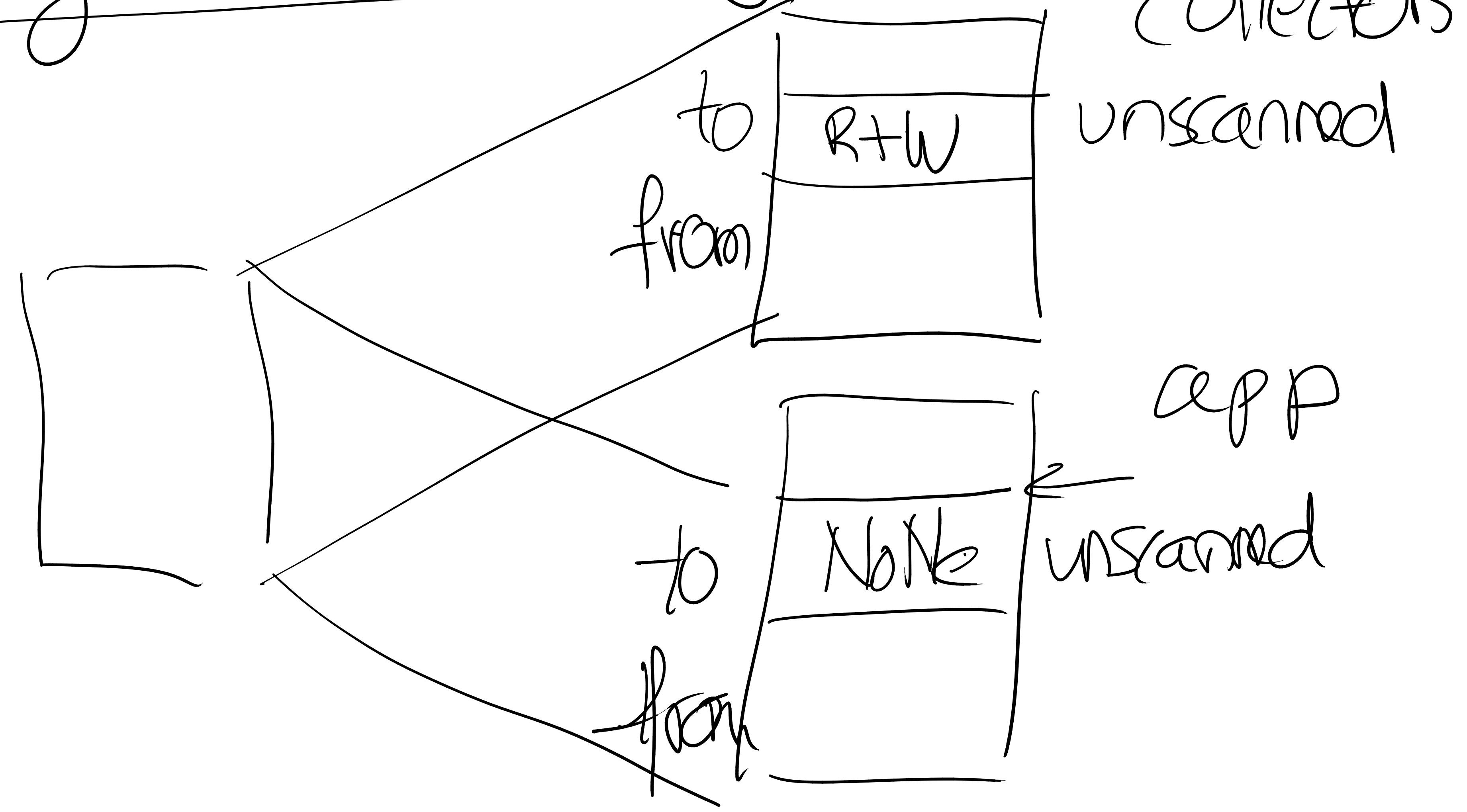
Scan one page of objects + forward them

unprotect the scanned page

+ incremental

+ No pointer check (the VM hw does it for us)

## Tricky issue w. concurrency: maps



## Should use VM?

Most cases could have been implemented w. extra instruct

$\hookrightarrow$ compiler()

Checkpointing

SVM

Unix supports them.

## What has changed 1491?

Many!

Continuous development

Some big changes:

- 5-levels
- ASID
- KPTI