ECS 235B Module 6
HRU Result

What Is “Secure”?

- Adding a generic right *r* where there was not one is “leaking”
  - In what follows, a right leaks if it was not present *initially*
  - Alternately: not present *in the previous state* (not discussed here)
- If a system *S*, beginning in initial state s_0, cannot leak right *r*, it is *safe with respect to the right r*
  - Otherwise it is called *unsafe with respect to the right r*

Safety Question

- Is there an algorithm for determining whether a protection system *S* with initial state s_0 is safe with respect to a generic right *r*?
  - Here, “safe” = “secure” for an abstract model

Mono-Operational Commands

- Answer: *yes*
- Sketch of proof:

  Consider minimal sequence of commands $c_1, \ldots, c_k$ to leak the right.
  - Can omit **delete**, **destroy** (with some rewriting)
  - Can merge all **create**s into one

  Worst case: insert every right into every entry; with s subjects and o objects initially, and n rights, upper bound is $k \leq n(s+1)(o+1)+1$

General Case

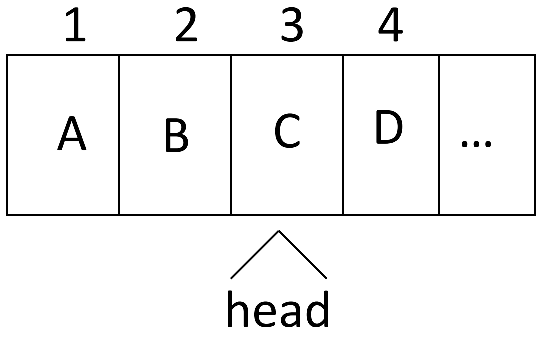
- Answer: *no*
- Sketch of proof:

  Reduce halting problem to safety problem

  Turing Machine review:

  - Infinite tape in one direction
  - States K, symbols M; distinguished blank b
  - Transition function $\delta(k, m) = (k', m', \mathrm{L})$ means in state k, symbol m on tape location replaced by symbol m', head moves to left one square, and enters state k'
  - Halting state is q_f; TM halts when it enters this state

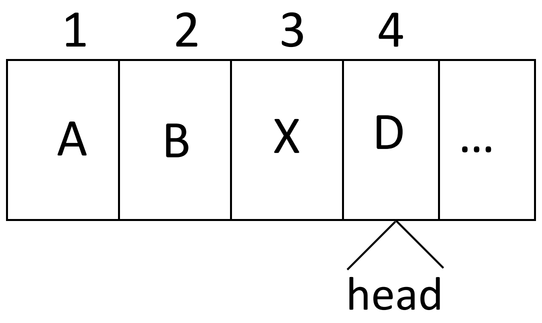
Mapping



Current state is *k*

	s_1	s_2	s_3	s_4	
s_1	A	*own*			
s_2		B	*own*		
s_3			C *k*	*own*	
s_4				D *end*	

Mapping



	s_1	s_2	s_3	s_4	
s_1	A	*own*			
s_2		B	*own*		
s_3			X	*own*	
s_4				D k_1 *end*	

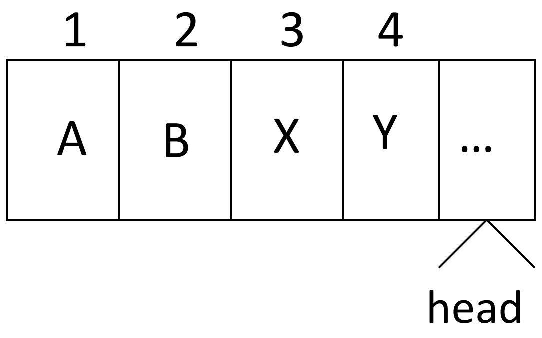
After $\delta(k, \text{C}) = (k_1, \text{X}, \text{R})$ where k is the current state and k_1 the next state

Command Mapping

- $\delta(k, \text{C}) = (k_1, \text{X}, \text{R})$ at intermediate becomes

```
command c_{k,C}(s_3,s_4)
if own in A[s_3,s_4] and k in A[s_3,s_3]
   and C in A[s_3,s_3]
then
 delete k from A[s_3,s_3];
 delete C from A[s_3,s_3];
 enter X into A[s_3,s_3];
 enter k_1 into A[s_4,s_4];
end
```

Mapping



	s_1	s_2	s_3	s_4	s_5
s_1	A	*own*			
s_2		B	*own*		
s_3			X	*own*	
s_4				Y	*own*
s_5					b k_2 end

After $\delta(k_1, \text{D}) = (k_2, \text{Y}, \text{R})$ where k_1 is the current state and k_2 the next state

Command Mapping

- $\delta(k_1, \mathrm{D}) = (k_2, \mathrm{Y}, \mathrm{R})$ at end becomes

```
command crightmost_{k,C}(s_4,s_5)
if end in A[s_4,s_4] and k_1 in A[s_4,s_4]
   and D in A[s_4,s_4]
then
  delete end from A[s_4,s_4];
  delete k_1 from A[s_4,s_4];
  delete D from A[s_4,s_4];
  enter Y into A[s_4,s_4];
  create subject s_5;
  enter own into A[s_4,s_5];
  enter end into A[s_5,s_5];
  enter k_2 into A[s_5,s_5];
end
```

Rest of Proof

- Protection system exactly simulates a TM
  - Exactly 1 *end* right in ACM
  - 1 right in entries corresponds to state
  - Thus, at most 1 applicable command
- If TM enters state q_f, then right has leaked
- If safety question decidable, then represent TM as above and determine if q_f leaks
  - Implies halting problem decidable
- Conclusion: safety question undecidable

Other Results

- Set of unsafe systems is recursively enumerable
- Delete **create** primitive; then safety question is complete in **P-SPACE**
- Delete **destroy**, **delete** primitives; then safety question is undecidable
    - Systems are monotonic
- Safety question for biconditional protection systems is decidable
- Safety question for monoconditional, monotonic protection systems is decidable
- Safety question for monoconditional protection systems with **create**, **enter**, **delete** (and no **destroy**) is decidable.

Quiz

The Harrison-Ruzzo-Ullman result says that the security question is undecidable. But it is also said we can determine whether a Linux system is secure for a given security policy. How would you resolve this apparent contradiction?

- The Linux claim is false for all security policies, just as the HRU result says.
- The Linux system is more general than the system in the HRU model, so the HRU result does not apply.
- There is no contradiction, as security policies for Linux systems are not so general as the security policy in the HRU model, and Linux systems are not as general as the system used in the HRU model.