CSCI 331:
Introduction to Computer Security

Lecture 9: Password Cracking, part 3

Instructor: Dan Barowy

Williams

Topics

Paper discussion

Generating PCHC chains

Generating Rainbow chains

Your to-dos

1. Lab 3 part 1, **due Sunday 10/8**.
2. Read *Smashing the Stack for Fun and Profit*, **for Thurs 10/12**.
3. Lab 3 part 2, **due Sunday 10/15**.
4. Midterm exam: **in class, Thursday, Oct 19**

Project Part 1 Partner Activity

Partner 1	*Partner 2*
David	Ye
Ben	Michelle
Faisal	Gregor
Sarah	Kit
Jack	Lee

Project Part 1 Partner Activity

1. **Find** assigned partner.
2. Spend **10 minutes reading** your partner's proposal.
3. Take **15 min discussing each proposal**. Prompts:
   a. **What** is the attack?
   b. **Who** can carry it out?
   c. **What** resource is at stake?
   d. **How** does the attack threaten:
      i) confidentiality
      ii) integrity/authenticity
      iii) availability
      iv) non-repudiation
   e. How **realistic** is implementation?

Project Activity

4. Think about how your conversation affected your thoughts on your project ideas.

Write down 2-3 concrete "next steps."
Take 2 minutes.

Suggestions:

- How you can improve writing.
- Additional background research.
- How to do a proof-of-concept.
- Resources you might need…

Project Part 1 Partner Activity

5. Think about the last step you took and, **right now, email me** a short evaluation of your proposal. The options are:
   - (`doh`) Didn't understand the assignment.
   - (`huh`) Missing some important points.
   - (`oic`) Generally good; could use clarification.
   - (`golly`) Perfect.

My email: dbarowy@cs.williams.edu

Generating Hash Chains with a Fixed Reducer

Example of length 4.

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: null
end: null

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: null
end: null

0000 ← genPlaintext(0)

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: null

0000 ← genPlaintext(0)

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 0000

0000 ← genPlaintext(0)

0000

dict

end	start
...	

genPlaintext(i)

start: 0000
end: 0000

0000 ← genPlaintext(0)

hash(p)

reduce(c)

0000

dict

end	start
...	

genPlaintext(i)

start: 0000
end: 0000

0000 ← genPlaintext(0)

4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

hash(p)

reduce(c)

0000

dict

end	start
...	

genPlaintext(i)

start: 0000
end: 0000

0000 ← genPlaintext(0)

4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)

hash(p)

reduce(c)

0000

dict

end	start
...	

genPlaintext(i)

start: 0000
end: 4A7D

0000 ← genPlaintext(0)

4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)

hash(p)

reduce(c)

r(h(p))
0000 → 4A7D

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 4A7D

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)

r(h(p))
0000 → 4A7D

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 4A7D

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)

r(h(p))
0000 → 4A7D

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 4A7D

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)

r(h(p))
0000 → 4A7D

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: DD75

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)

0000 —r(h(p))→ 4A7D —r(h(p))→ DD75

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: DD75

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)

0000 —r(h(p))→ 4A7D —r(h(p))→ DD75

HashMap<String,String> dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: DD75

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)

0000 —r(h(p))→ 4A7D —r(h(p))→ DD75

HashMap<String,String> dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: DD75

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)

0000 —r(h(p))→ 4A7D —r(h(p))→ DD75

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 7539

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)

0000 —r(h(p))→ 4A7D —r(h(p))→ DD75 —r(h(p))→ 7539

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 7539

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)

0000 —r(h(p))→ 4A7D —r(h(p))→ DD75 —r(h(p))→ 7539

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 7539

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)
4AADD661908B181D059A117F02FBC9EC ← hash(7539)

0000 —r(h(p))→ 4A7D —r(h(p))→ DD75 —r(h(p))→ 7539

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 7539

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)
4AADD661908B181D059A117F02FBC9EC ← hash(7539)
4AAD ← reduce(4AADD661908B181D059A117F02FBC9EC)

0000 —r(h(p))→ 4A7D —r(h(p))→ DD75 —r(h(p))→ 7539

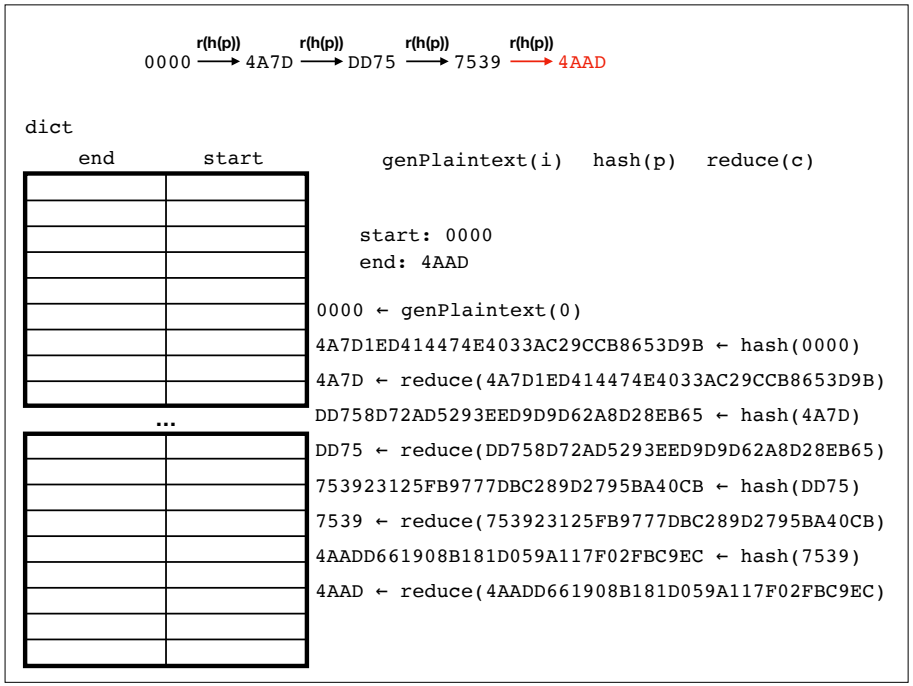
dict

end	start
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 4AAD

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)
4AADD661908B181D059A117F02FBC9EC ← hash(7539)
4AAD ← reduce(4AADD661908B181D059A117F02FBC9EC)


0000 r(h(p)) 4A7D r(h(p)) DD75 r(h(p)) 7539 r(h(p)) 4AAD
dict
end
start
genPlaintext(i)
hash(p)
reduce(c)
...
start: 0000
end: 4AAD
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
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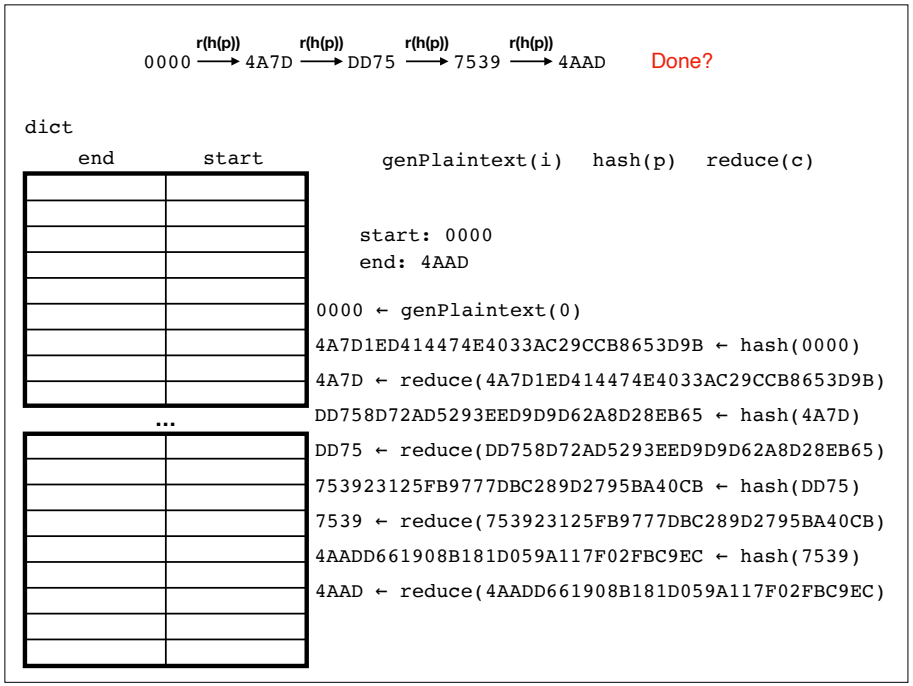
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)
4AADD661908B181D059A117F02FBC9EC ← hash(7539)
4AAD ← reduce(4AADD661908B181D059A117F02FBC9EC)


0000 r(h(p)) 4A7D r(h(p)) DD75 r(h(p)) 7539 r(h(p)) 4AAD
Done?
dict
end
start
genPlaintext(i)
hash(p)
reduce(c)
...
start: 0000
end: 4AAD
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
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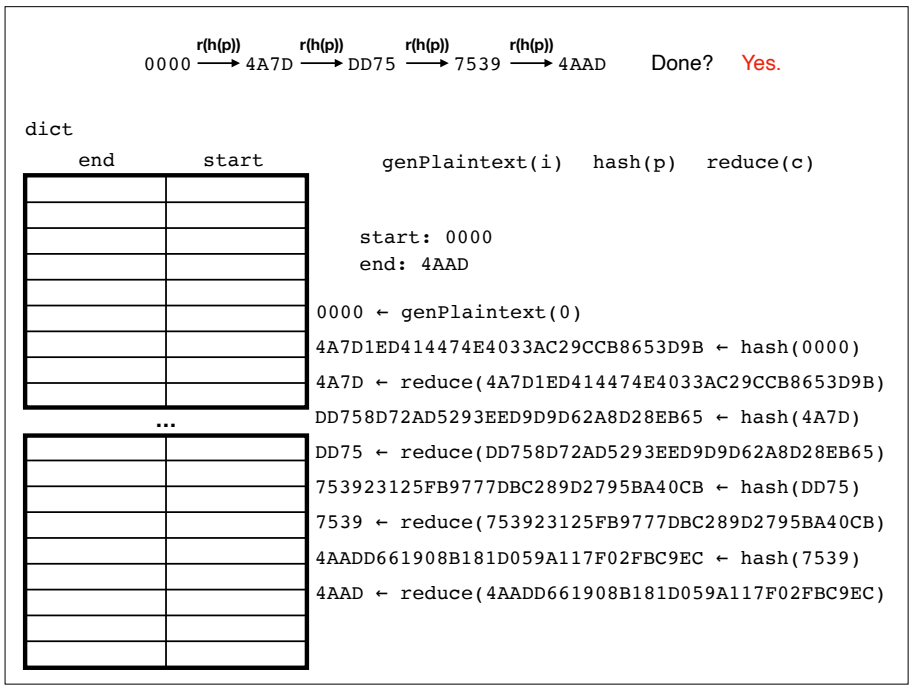
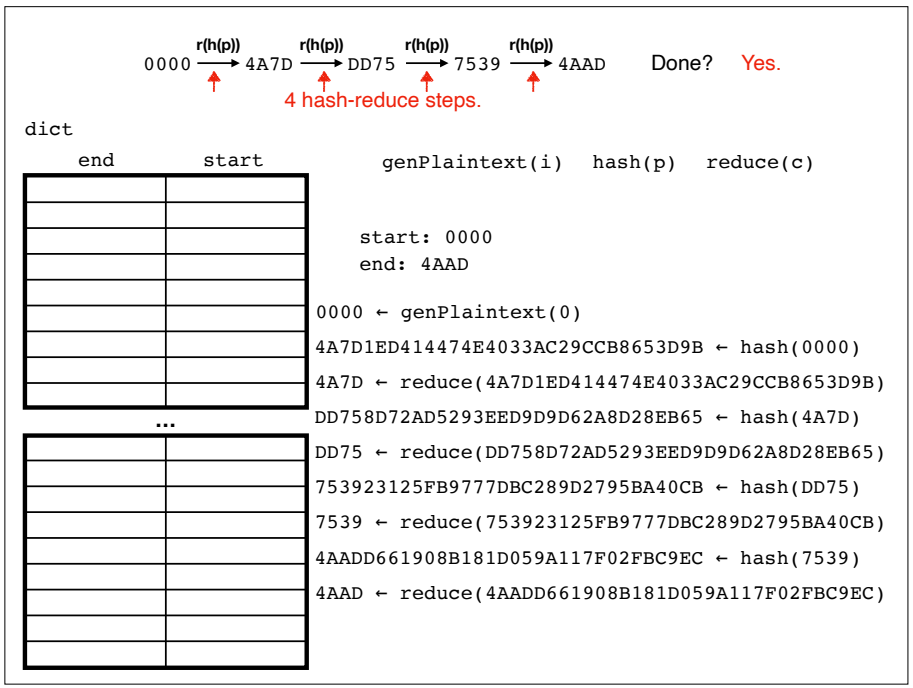
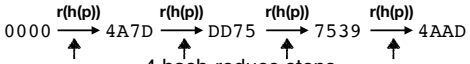
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)
4AADD661908B181D059A117F02FBC9EC ← hash(7539)
4AAD ← reduce(4AADD661908B181D059A117F02FBC9EC)


0000 r(h(p)) 4A7D r(h(p)) DD75 r(h(p)) 7539 r(h(p)) 4AAD
Done?
Yes.
dict
end
start
genPlaintext(i)
hash(p)
reduce(c)
...
start: 0000
end: 4AAD
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)
4AADD661908B181D059A117F02FBC9EC ← hash(7539)
4AAD ← reduce(4AADD661908B181D059A117F02FBC9EC)


0000 r(h(p)) 4A7D r(h(p)) DD75 r(h(p)) 7539 r(h(p)) 4AAD
Done?
Yes.
4 hash-reduce steps.
dict
end
start
genPlaintext(i)
hash(p)
reduce(c)
...
start: 0000
end: 4AAD
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)
4AADD661908B181D059A117F02FBC9EC ← hash(7539)
4AAD ← reduce(4AADD661908B181D059A117F02FBC9EC)



Done? Yes.

dict

end	start
4AAD	0000
...	

genPlaintext(i) hash(p) reduce(c)

start: 0000
end: 4AAD

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
DD75 ← reduce(DD758D72AD5293EED9D9D62A8D28EB65)
753923125FB9777DBC289D2795BA40CB ← hash(DD75)
7539 ← reduce(753923125FB9777DBC289D2795BA40CB)
4AADD661908B181D059A117F02FBC9EC ← hash(7539)
4AAD ← reduce(4AADD661908B181D059A117F02FBC9EC)

dict

end	start
4AAD	0000
...	

genPlaintext(i) hash(p) reduce(c)

start: null
end: null

0001 ← genPlaintext(1)

dict

end	start
4AAD	0000
...	

genPlaintext(i) hash(p) reduce(c)

start: 0001
end: null

0001 ← genPlaintext(1)

dict

end	start
4AAD	0000
...	

genPlaintext(i) hash(p) reduce(c)

start: 0001
end: 0001

0001 ← genPlaintext(1)

0001

dict

end	start
4AAD	0000
...	

genPlaintext(i) hash(p) reduce(c)

start: 0001
end: 0001

0001 ← genPlaintext(1)

0001

dict

end	start
4AAD	0000
...	

genPlaintext(i) hash(p) reduce(c)

start: 0001
end: 0001

0001 ← genPlaintext(1)

And so on…

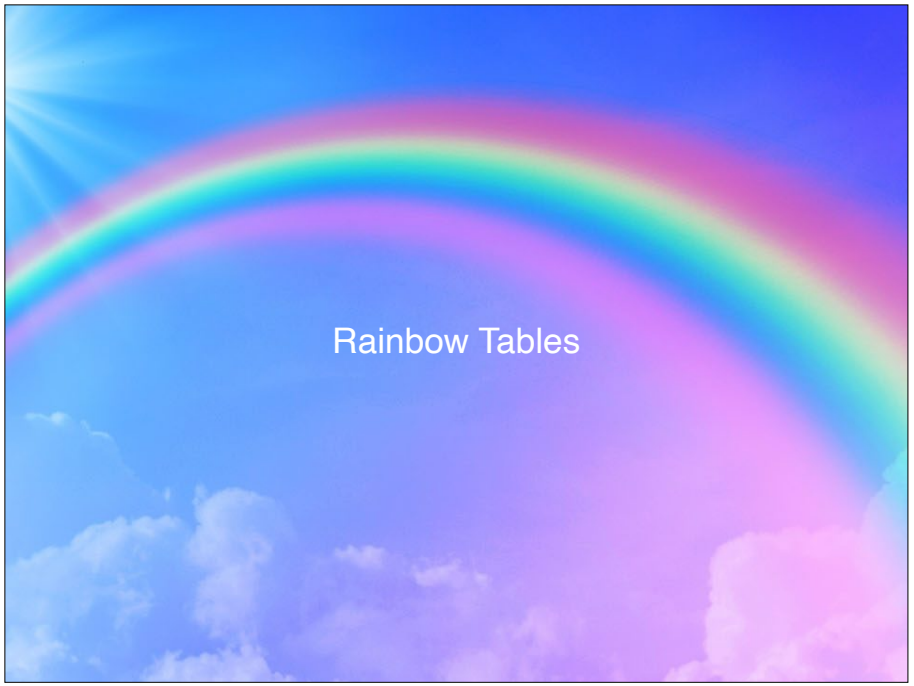
Question

Previous CS331 student:
“If we **enumerate** all keys, don’t we have **duplication** in our table?”

Question

Can a precomputed hash chain **decrypt all hashes**?

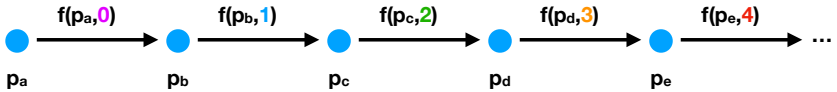
Paper discussion



Why “rainbow table”?

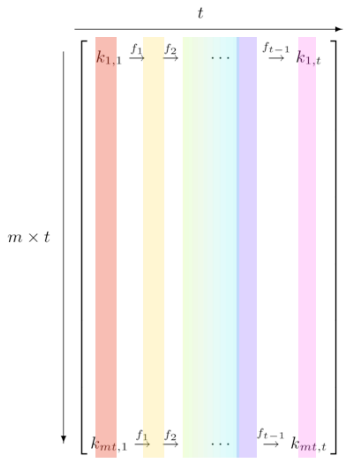
Rainbow tables are a tiny modification to PCHC tables:
The reducer function **changes at each link i in the chain**.

Let f(p, i) = $\text{reduce}_i(\text{hash}(p))$



It’s like a “rainbow” of reducer functions.

Why “rainbow table”?



dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: null
end: null

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: null
end: null

0000 ← genPlaintext(0)

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: null

0000 ← genPlaintext(0)

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: 0000

0000 ← genPlaintext(0)

0000

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: 0000

0000 ← genPlaintext(0)

0000

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: 0000

0000 ← genPlaintext(0)

4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

0000

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: 0000

0000 ← genPlaintext(0)

4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

4A7D ← reduce(4A7D1ED414…, 0)

0000

dict

end	start

...

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: 4A7D

0000 ← genPlaintext(0)

4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

4A7D ← reduce(4A7D1ED414…, 0)

r(h(p))
0000 → 4A7D

dict

end	start

...

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: 4A7D

0000 ← genPlaintext(0)

4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

4A7D ← reduce(4A7D1ED414…, 0)

r(h(p))
0000 → 4A7D

dict

end	start

...

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: 4A7D

0000 ← genPlaintext(0)

4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

4A7D ← reduce(4A7D1ED414…, 0)

DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)

r(h(p))
0000 → 4A7D

dict

end	start

...

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: 4A7D

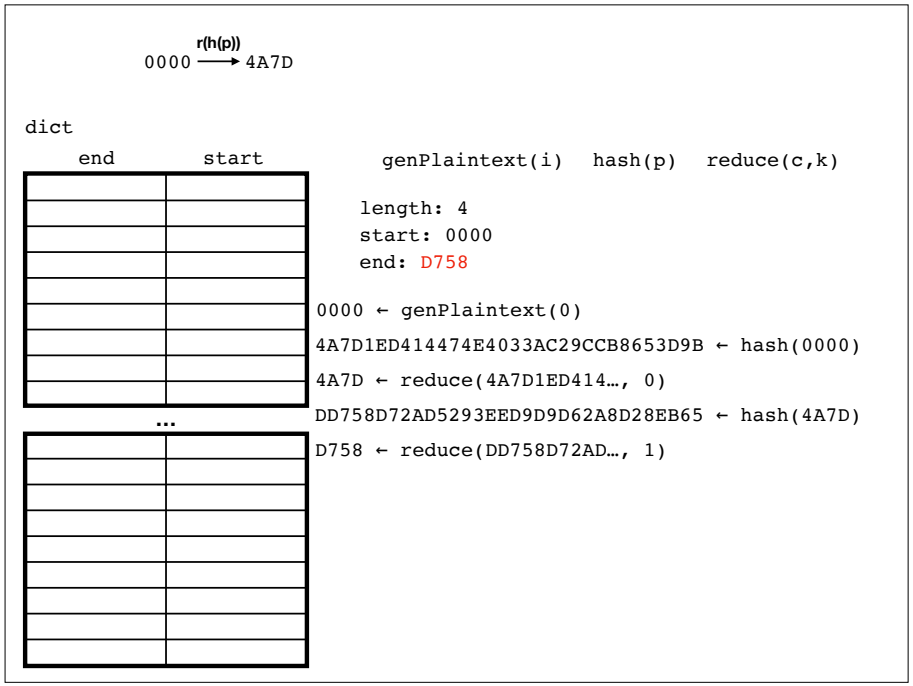
0000 ← genPlaintext(0)

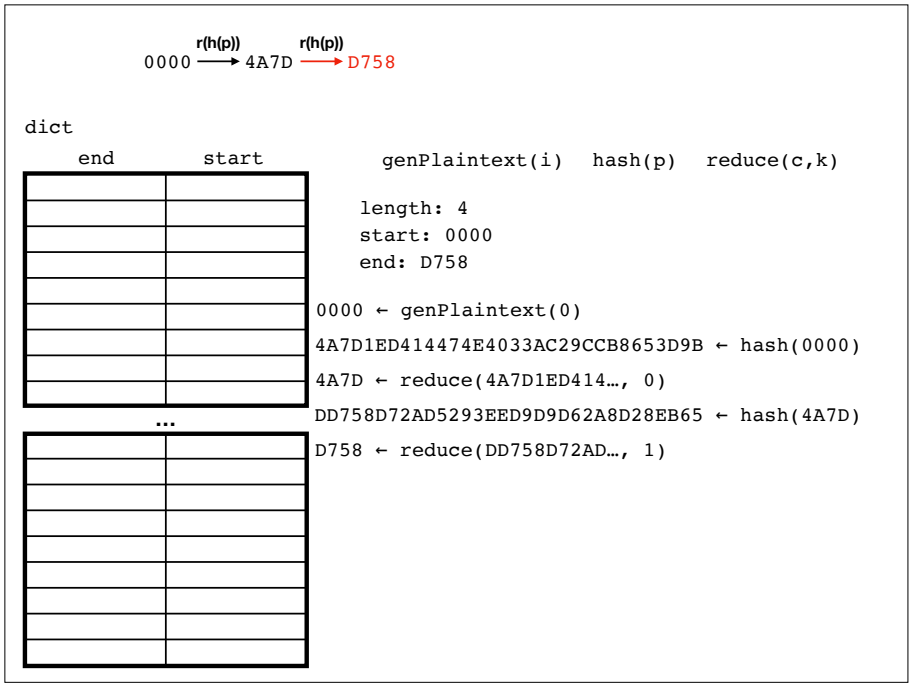
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)

4A7D ← reduce(4A7D1ED414…, 0)

DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)

D758 ← reduce(DD758D72AD…, 1)


r(h(p))
0000 → 4A7D
dict
end
start
genPlaintext(i)
hash(p)
reduce(c,k)
length: 4
start: 0000
end: D758
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
...


r(h(p))
r(h(p))
0000 → 4A7D → D758
dict
end
start
genPlaintext(i)
hash(p)
reduce(c,k)
length: 4
start: 0000
end: D758
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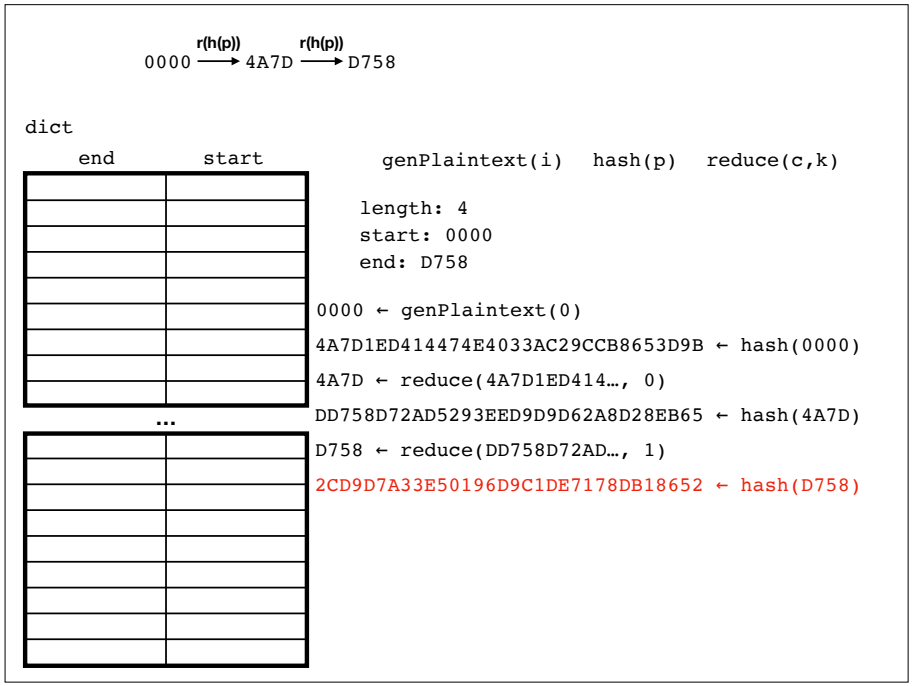
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
...


r(h(p))
r(h(p))
0000 → 4A7D → D758
dict
end
start
genPlaintext(i)
hash(p)
reduce(c,k)
length: 4
start: 0000
end: D758
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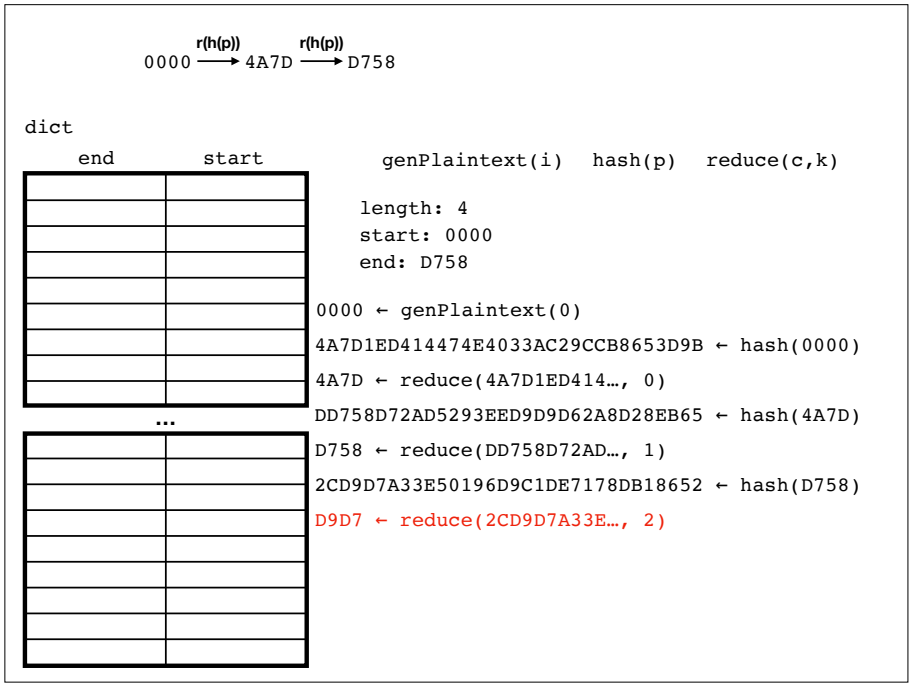
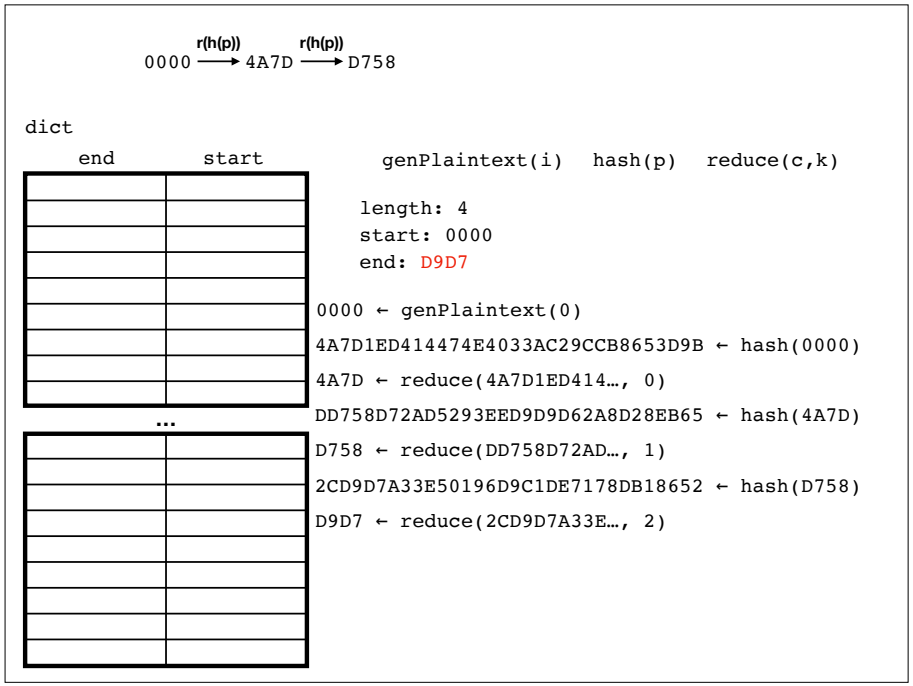
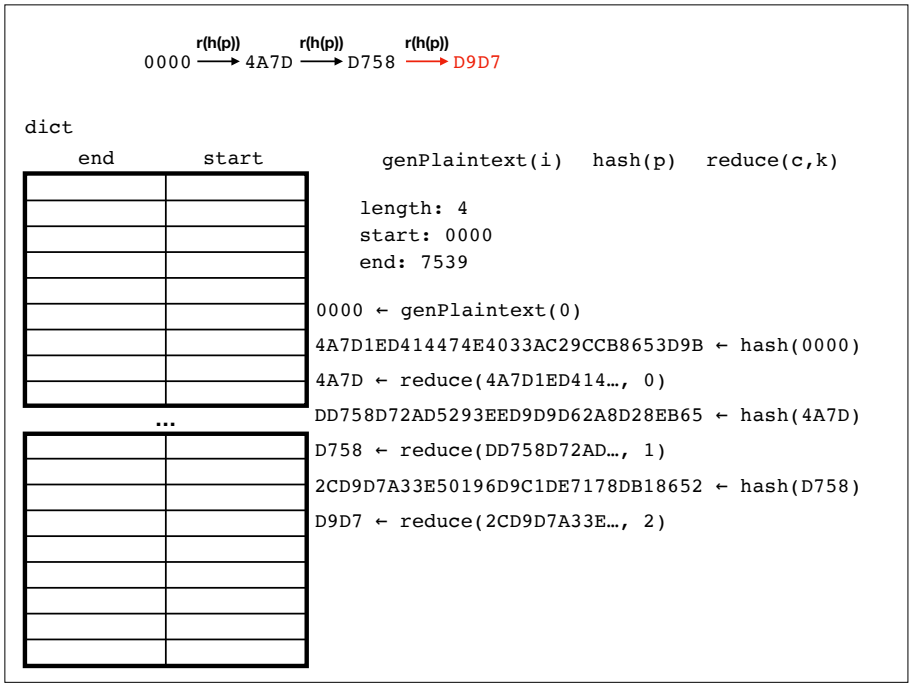
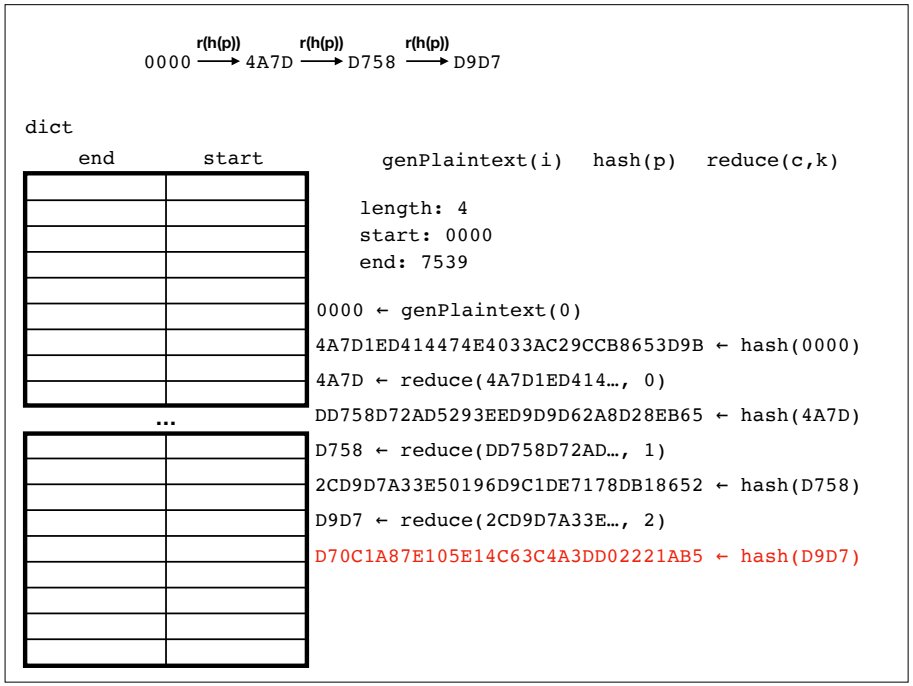
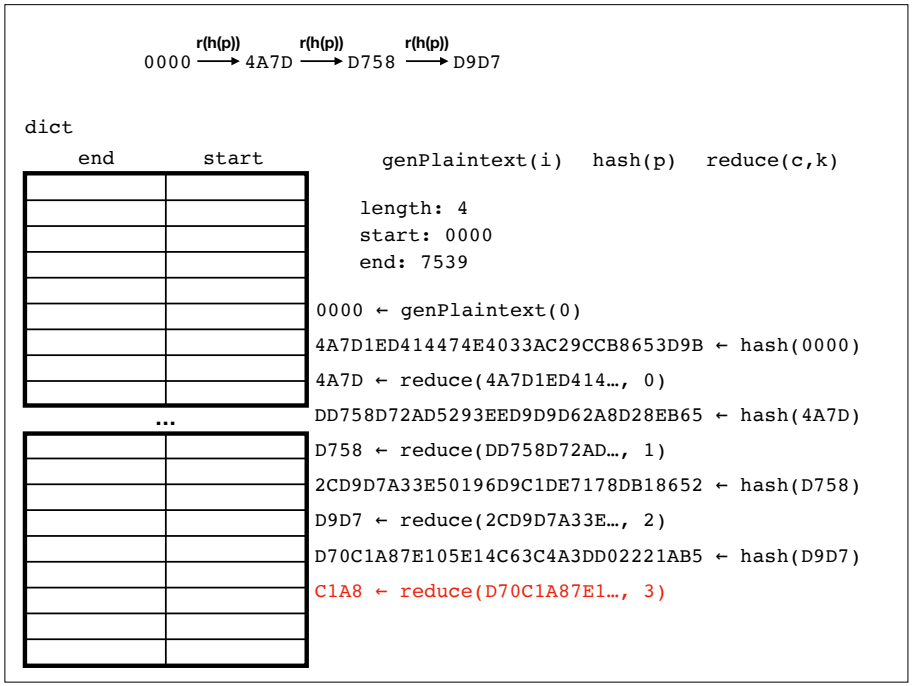
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
...


r(h(p))
r(h(p))
0000 → 4A7D → D758
dict
end
start
genPlaintext(i)
hash(p)
reduce(c,k)
length: 4
start: 0000
end: D758
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
...


r(h(p))
r(h(p))
0000
4A7D
D758
dict
end
start
genPlaintext(i)
hash(p)
reduce(c,k)
length: 4
start: 0000
end: D9D7
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
...


r(h(p))
r(h(p))
r(h(p))
0000
4A7D
D758
D9D7
dict
end
start
genPlaintext(i)
hash(p)
reduce(c,k)
length: 4
start: 0000
end: 7539
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
...


r(h(p))
r(h(p))
r(h(p))
0000
4A7D
D758
D9D7
dict
end
start
genPlaintext(i)
hash(p)
reduce(c,k)
length: 4
start: 0000
end: 7539
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
D70C1A87E105E14C63C4A3DD02221AB5 ← hash(D9D7)
...


r(h(p))
r(h(p))
r(h(p))
0000
4A7D
D758
D9D7
dict
end
start
genPlaintext(i)
hash(p)
reduce(c,k)
length: 4
start: 0000
end: 7539
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
D70C1A87E105E14C63C4A3DD02221AB5 ← hash(D9D7)
C1A8 ← reduce(D70C1A87E1…, 3)
...

0000 —r(h(p))→ 4A7D —r(h(p))→ D758 —r(h(p))→ D9D7

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: C1A8

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414474E4033AC29CCB8653D9B)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
D70C1A87E105E14C63C4A3DD02221AB5 ← hash(D9D7)
C1A8 ← reduce(D70C1A87E1…, 3)

0000 —r(h(p))→ 4A7D —r(h(p))→ D758 —r(h(p))→ D9D7 —r(h(p))→ C1A8

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: C1A8

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
D70C1A87E105E14C63C4A3DD02221AB5 ← hash(D9D7)
C1A8 ← reduce(D70C1A87E1…, 3)

0000 —r(h(p))→ 4A7D —r(h(p))→ D758 —r(h(p))→ D9D7 —r(h(p))→ C1A8 Done?

dict

end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: C1A8

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
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D9D7 ← reduce(2CD9D7A33E…, 2)
D70C1A87E105E14C63C4A3DD02221AB5 ← hash(D9D7)
C1A8 ← reduce(D70C1A87E1…, 3)

0000 —r(h(p))→ 4A7D —r(h(p))→ D758 —r(h(p))→ D9D7 —r(h(p))→ C1A8 Done? Yes.

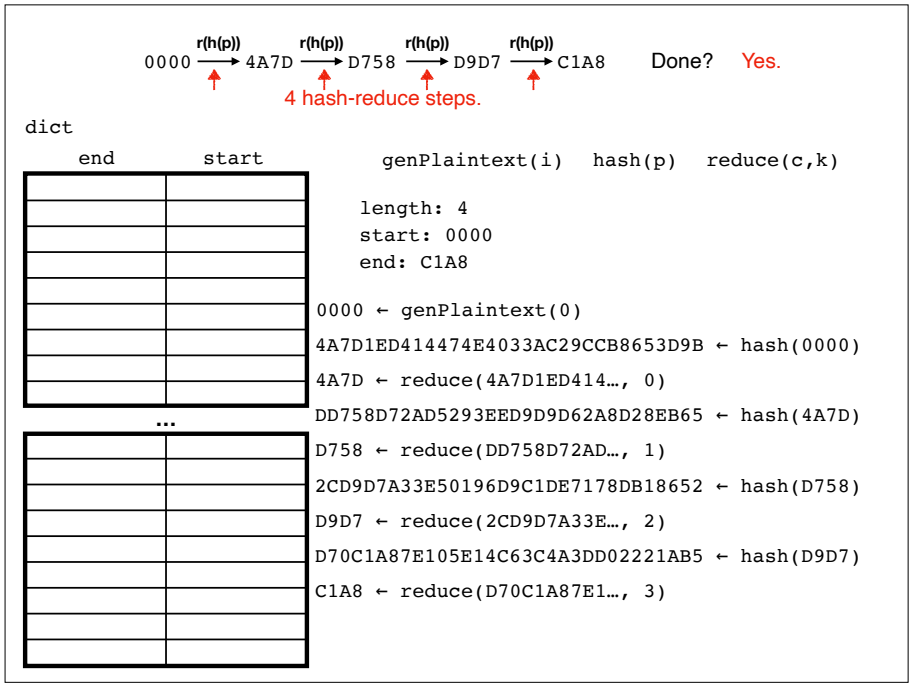
dict

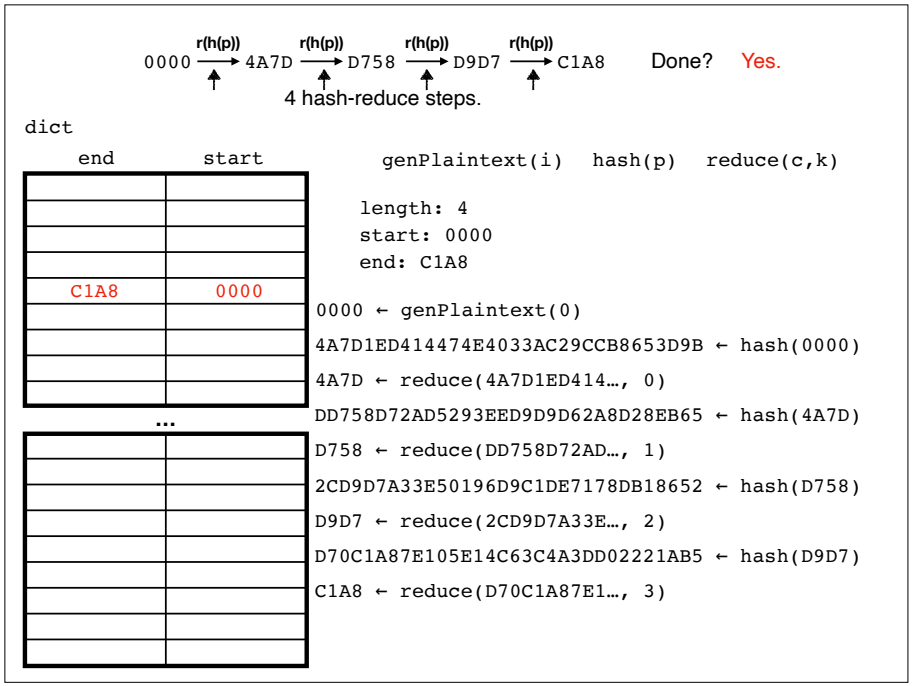
end	start
...	

genPlaintext(i) hash(p) reduce(c,k)

length: 4
start: 0000
end: C1A8

0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
D70C1A87E105E14C63C4A3DD02221AB5 ← hash(D9D7)
C1A8 ← reduce(D70C1A87E1…, 3)


0000 r(h(p)) 4A7D r(h(p)) D758 r(h(p)) D9D7 r(h(p)) C1A8 Done? Yes.
4 hash-reduce steps.
dict
end start
genPlaintext(i) hash(p) reduce(c,k)
length: 4
start: 0000
end: C1A8
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
2CD9D7A33E50196D9C1DE7178DB18652 ← hash(D758)
D9D7 ← reduce(2CD9D7A33E…, 2)
D70C1A87E105E14C63C4A3DD02221AB5 ← hash(D9D7)
C1A8 ← reduce(D70C1A87E1…, 3)


0000 r(h(p)) 4A7D r(h(p)) D758 r(h(p)) D9D7 r(h(p)) C1A8 Done? Yes.
4 hash-reduce steps.
dict
end start
genPlaintext(i) hash(p) reduce(c,k)
C1A8 0000
length: 4
start: 0000
end: C1A8
0000 ← genPlaintext(0)
4A7D1ED414474E4033AC29CCB8653D9B ← hash(0000)
4A7D ← reduce(4A7D1ED414…, 0)
DD758D72AD5293EED9D9D62A8D28EB65 ← hash(4A7D)
D758 ← reduce(DD758D72AD…, 1)
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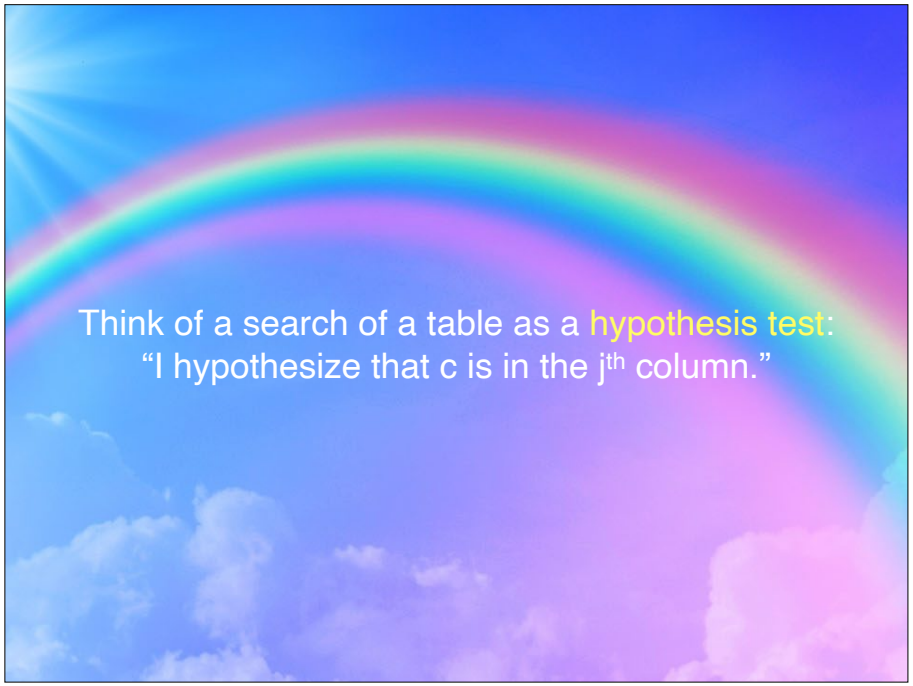
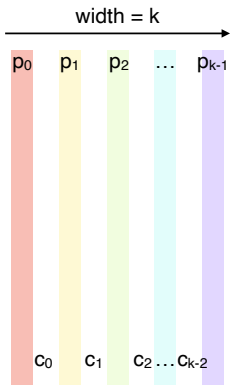
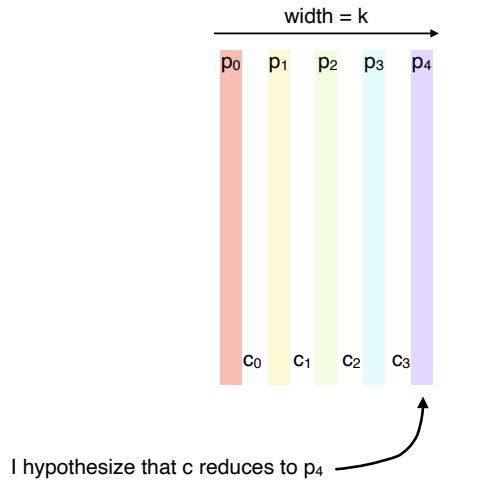
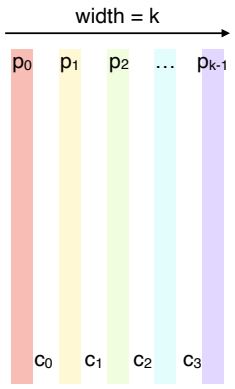
D9D7 ← reduce(2CD9D7A33E…, 2)
D70C1A87E105E14C63C4A3DD02221AB5 ← hash(D9D7)
C1A8 ← reduce(D70C1A87E1…, 3)


Think of a table search as two operations:
• Finding the column of the ciphertext.
• Finding the ciphertext within a row.


Think of a search of a table as a hypothesis test:
“I hypothesize that c is in the jth column.”







I hypothesize that c reduces to p_{k-2}

What reducer should I use? `reduce(c,2)`

Then: `reduce(c,3)`

Recap & Next Class

Today we learned:

PCHC generation

Rainbow table generation

Next class:

Classes of program bugs