Hash Functions in Action

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Lecture 12

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- Today: UOWHF and CRHF constructions. Domain Extension.
  Applications of hash functions

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    - Will see later, how to extend the domain to arbitrarily long strings (without increasing output size)

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  - All candidates use mathematical operations that are considered computationally expensive

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  - Hash halves the size of the input

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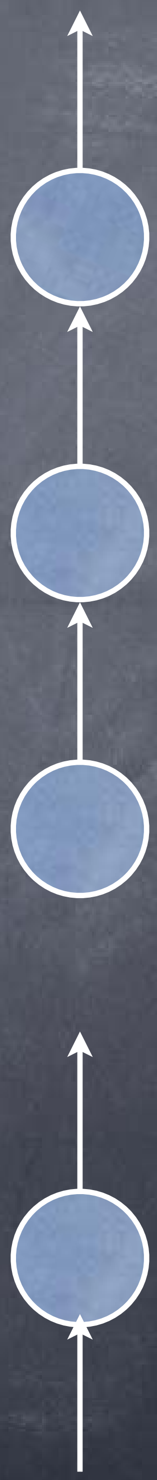

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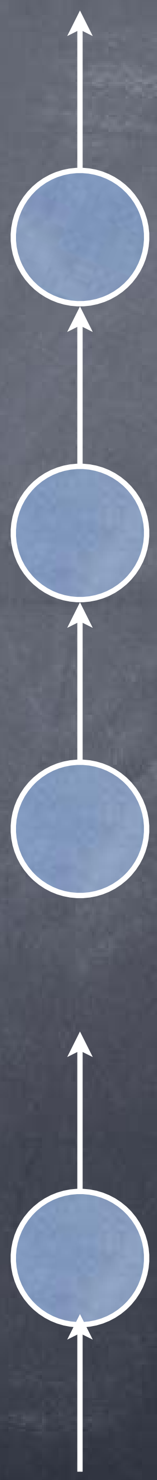

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  - Depends!

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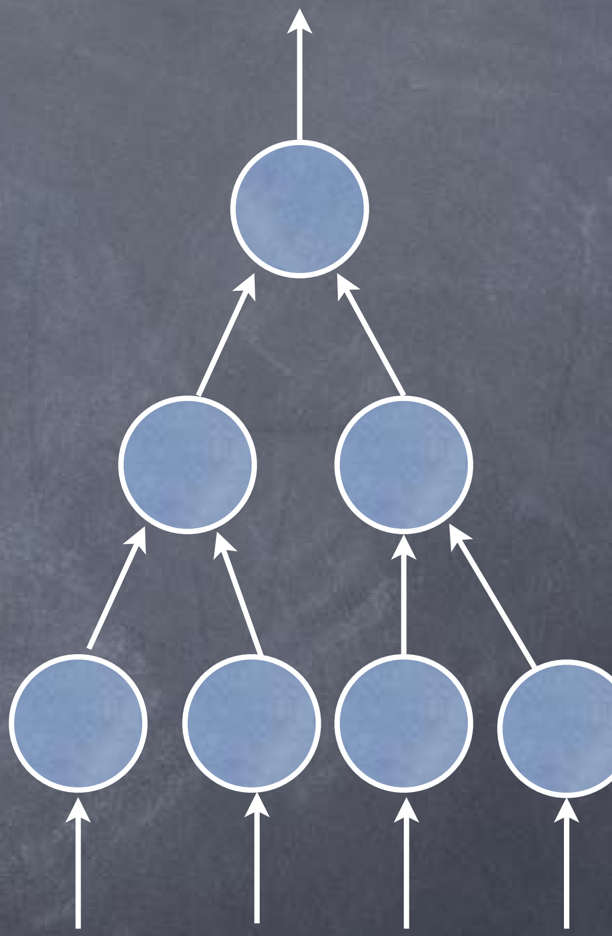

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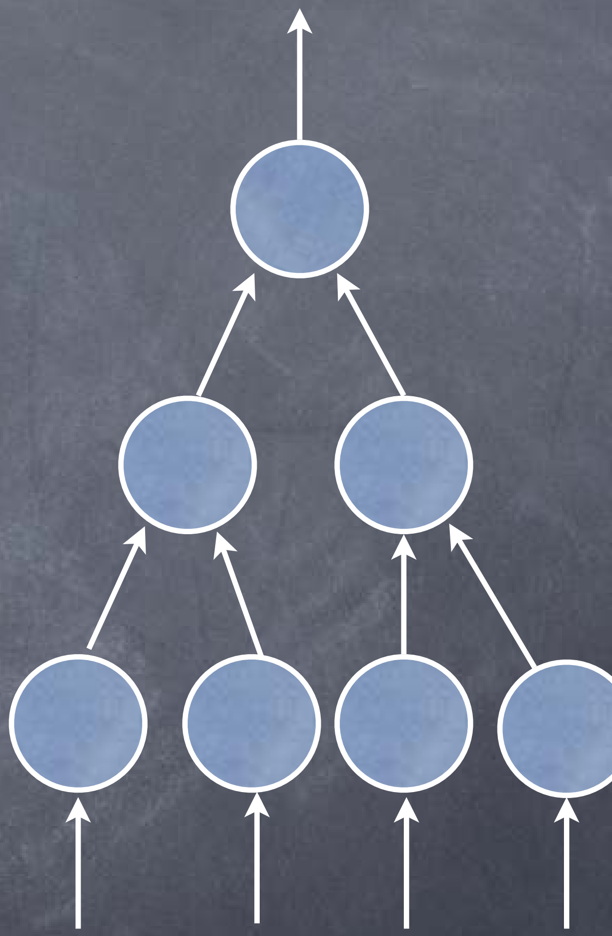

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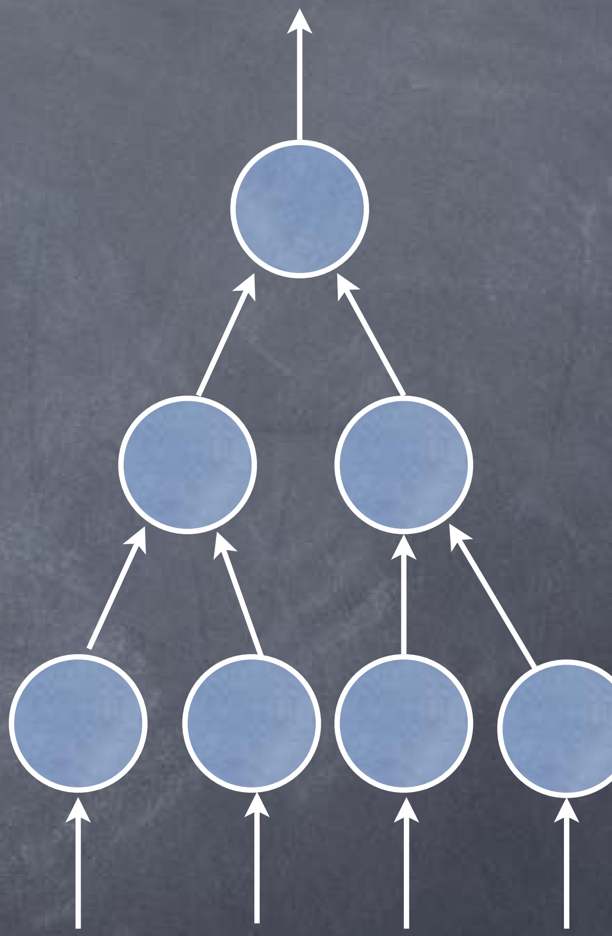

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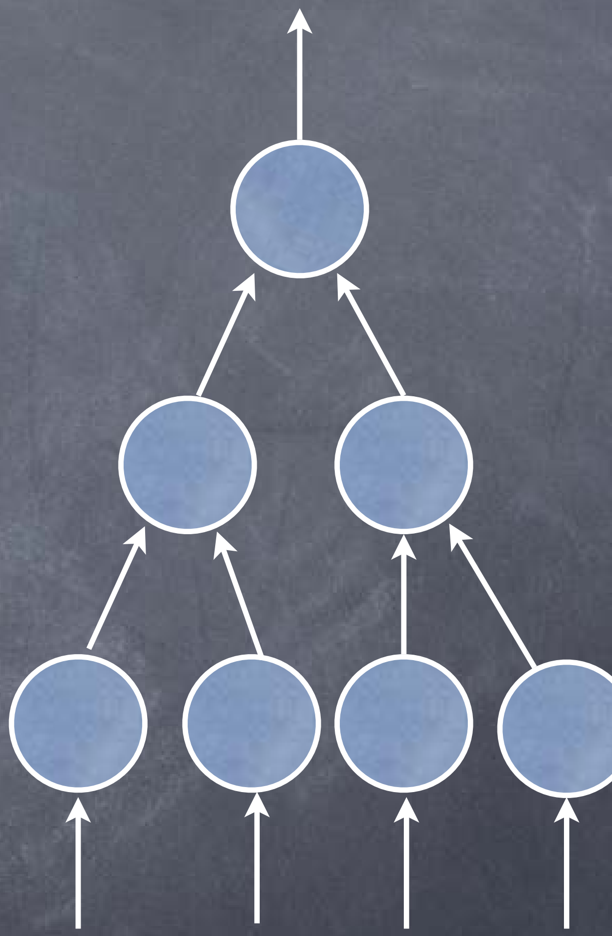

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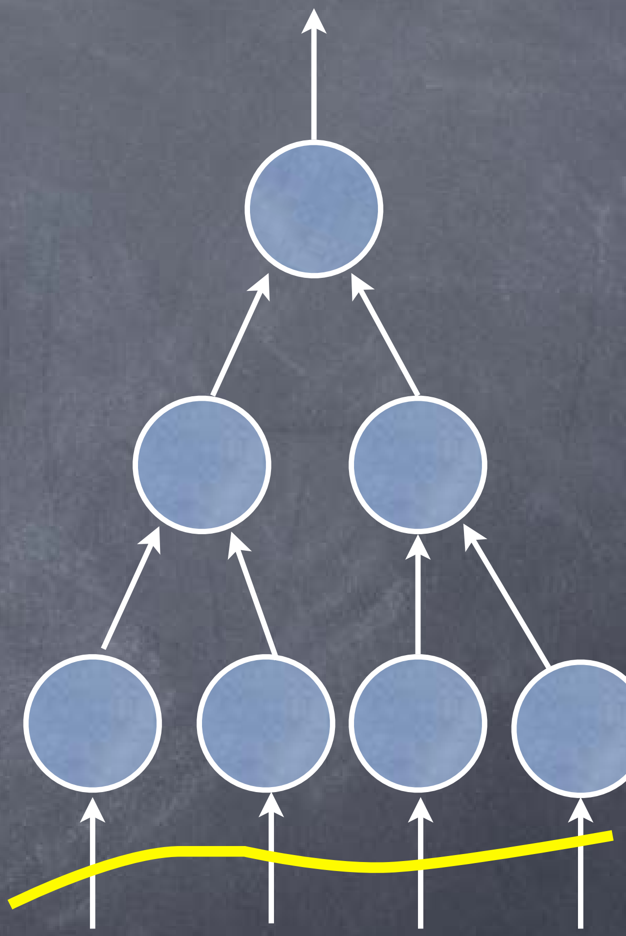

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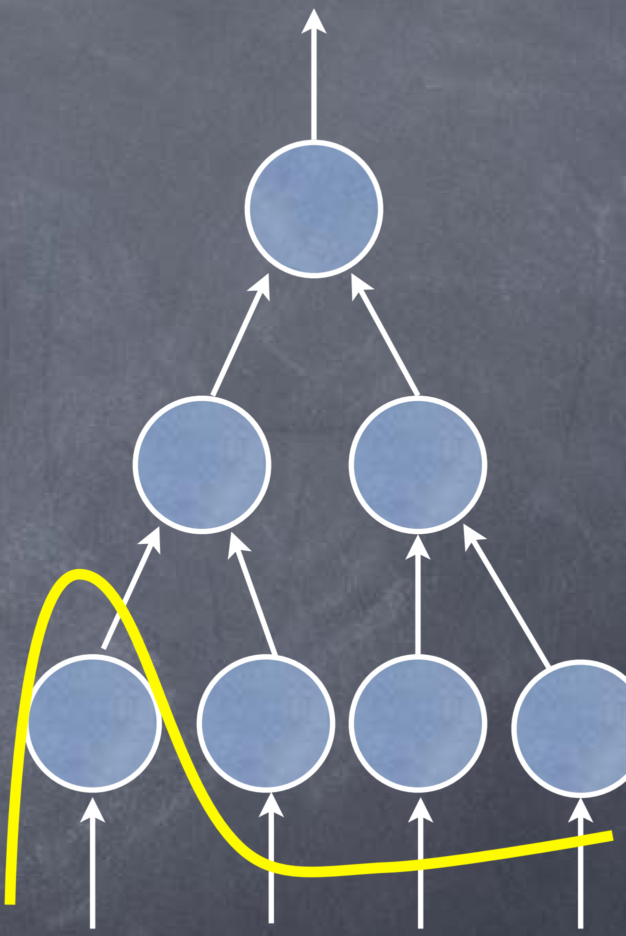

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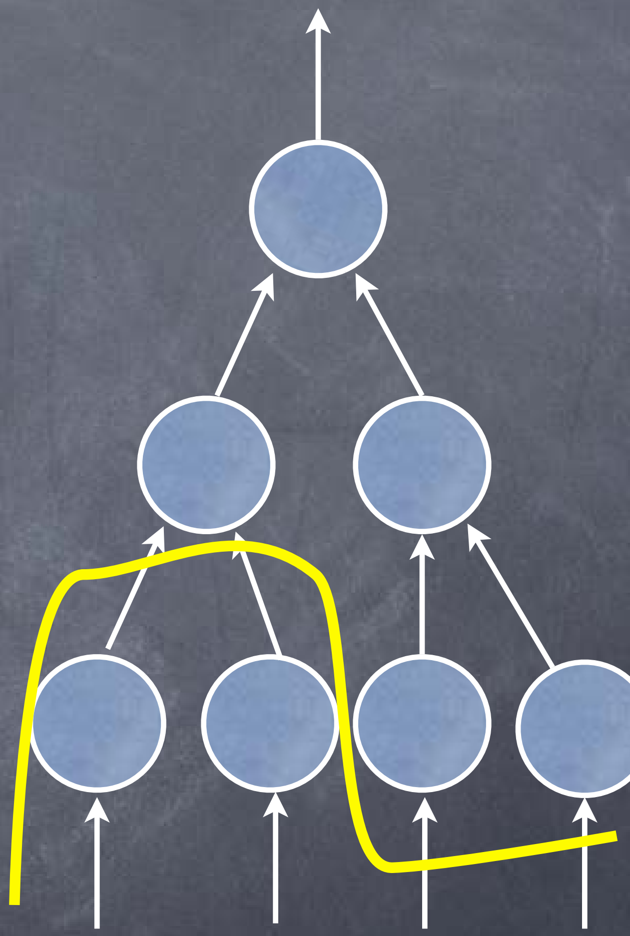

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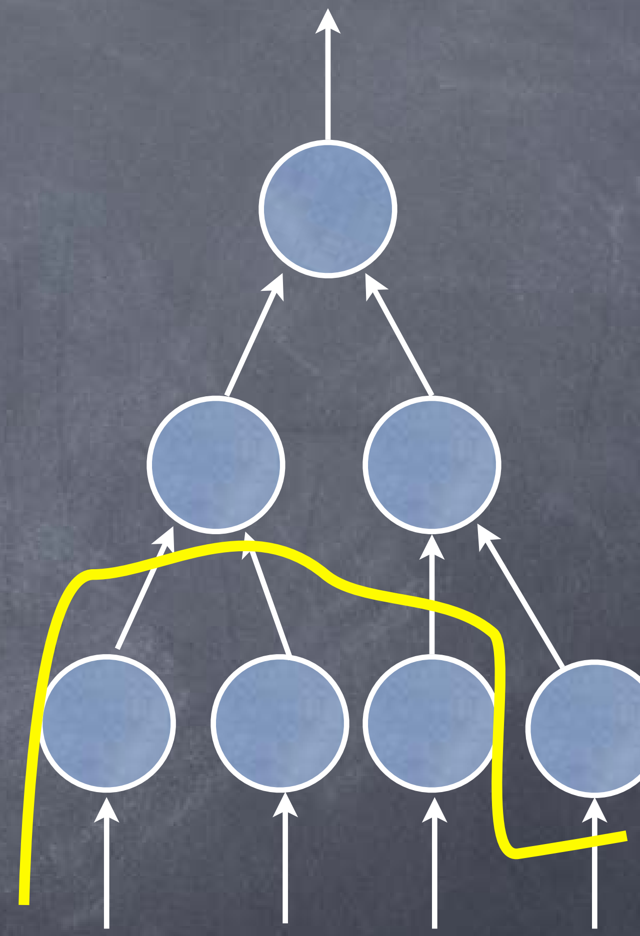

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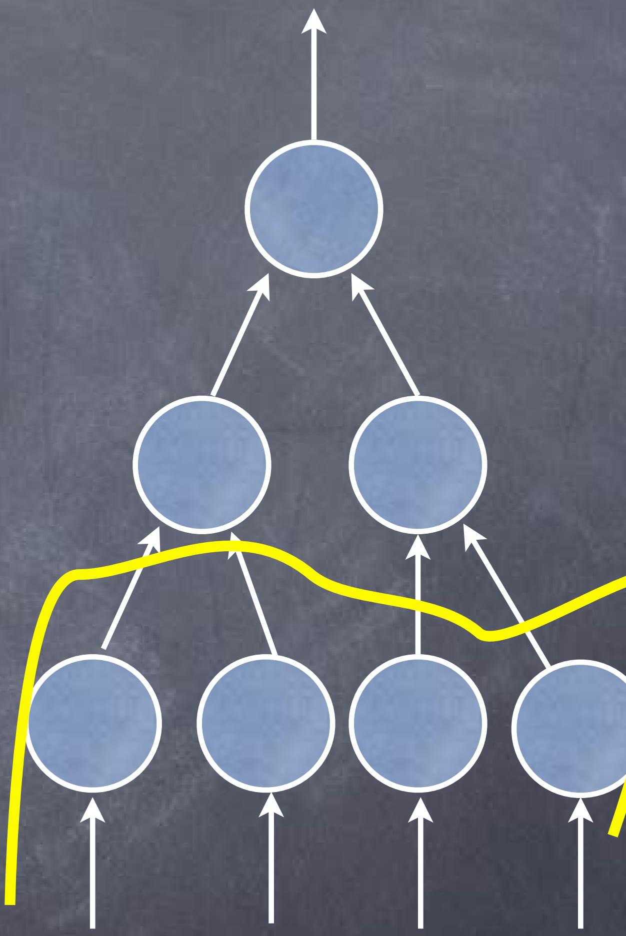

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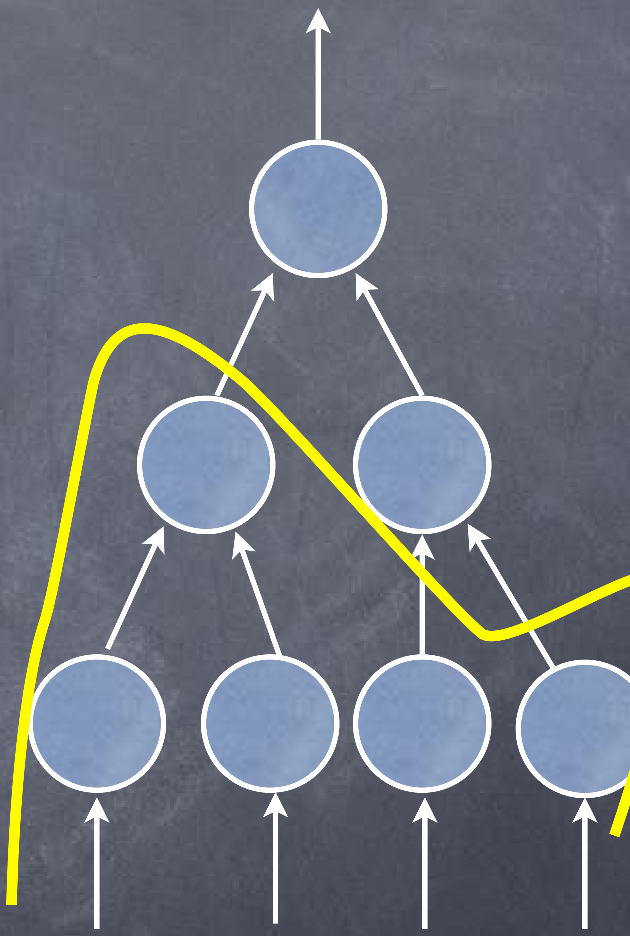

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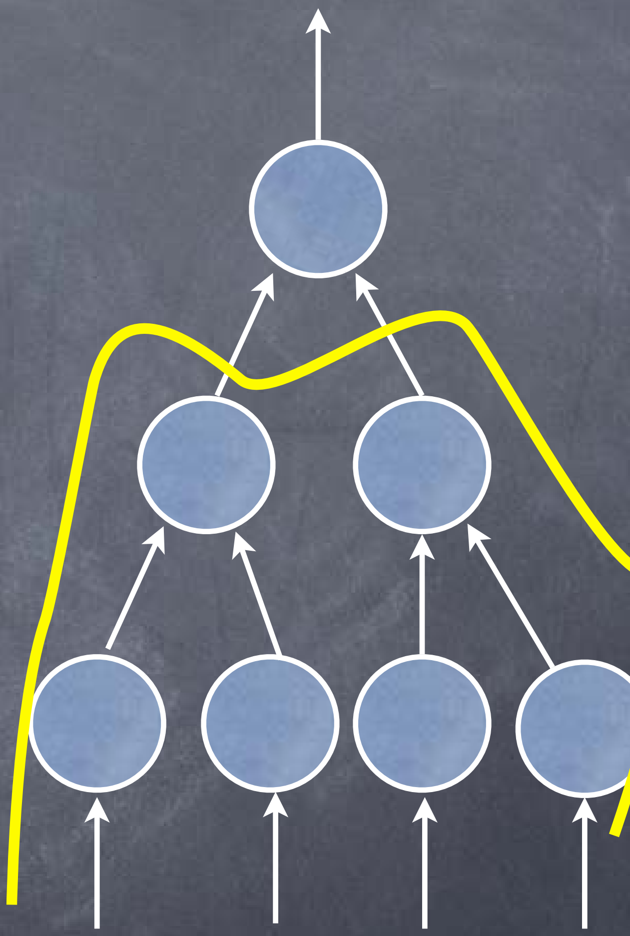

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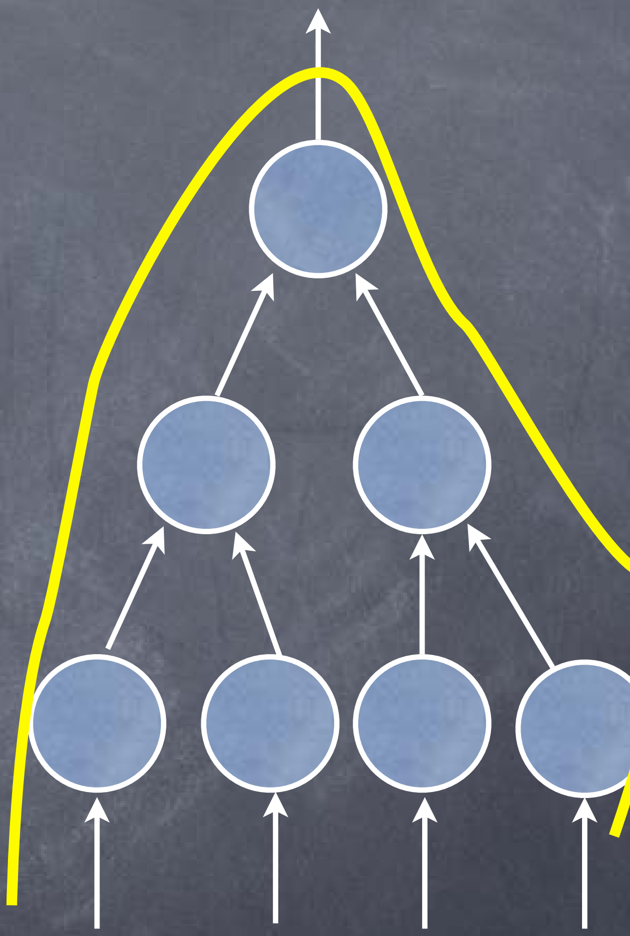

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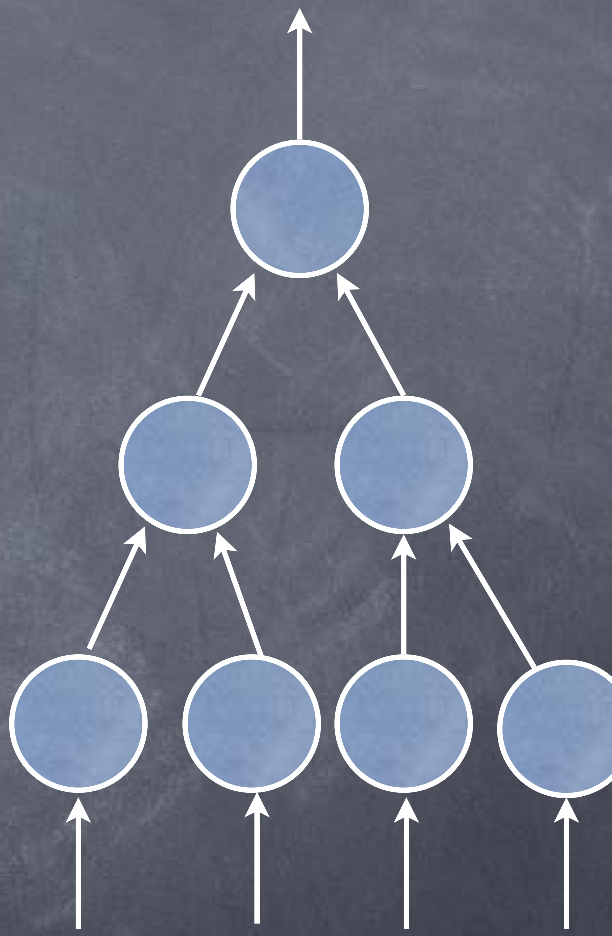

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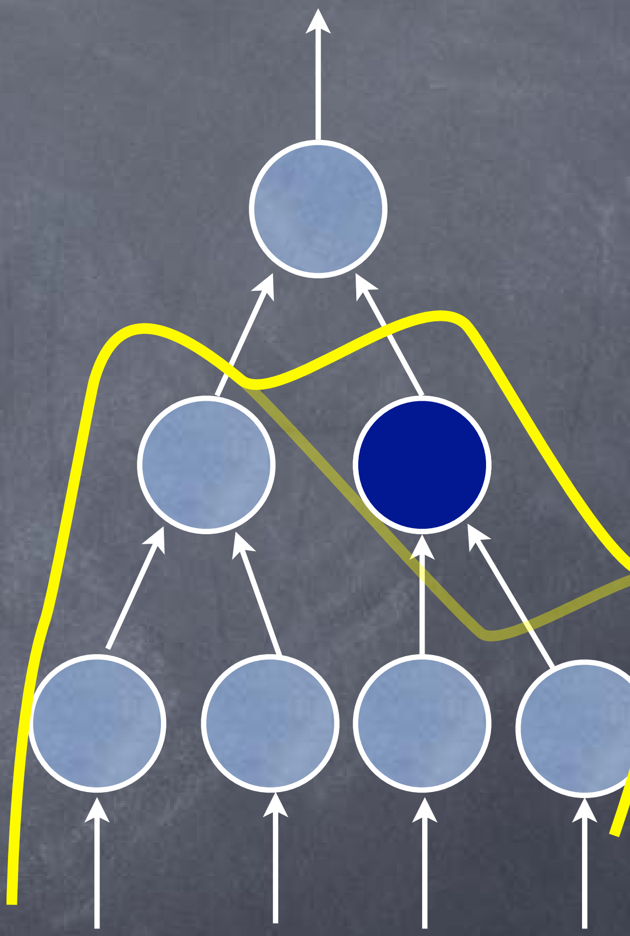

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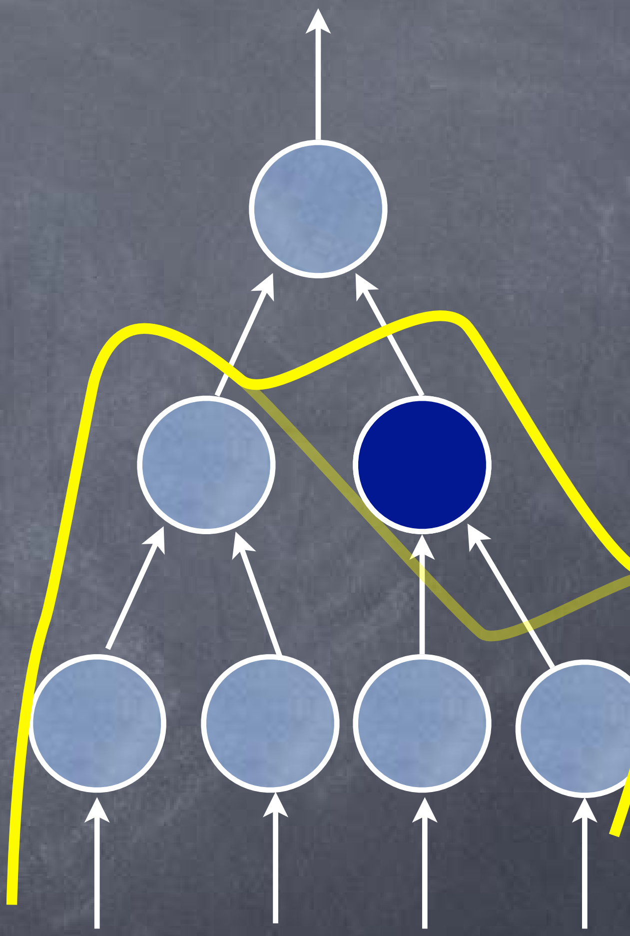
- $A^*(h)$: run $A(h)$ to get $(x_1 \ldots x_n)$, $(y_1 \ldots y_n)$. Move frontline to find (x',y')



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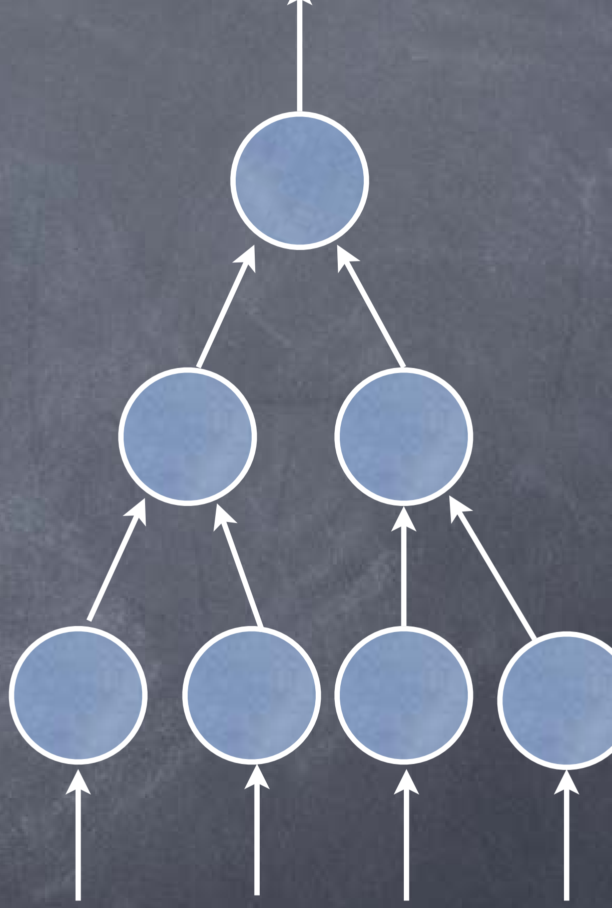

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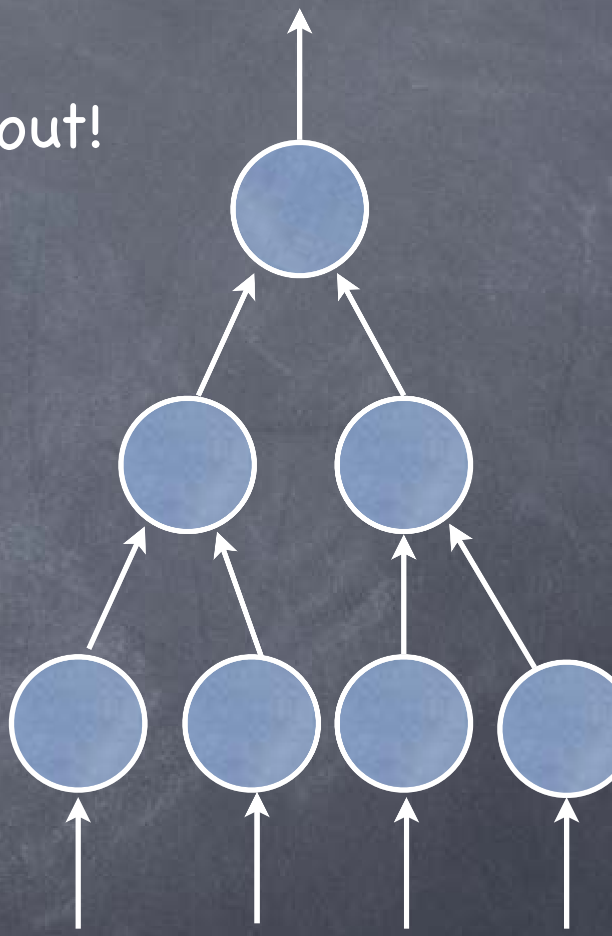

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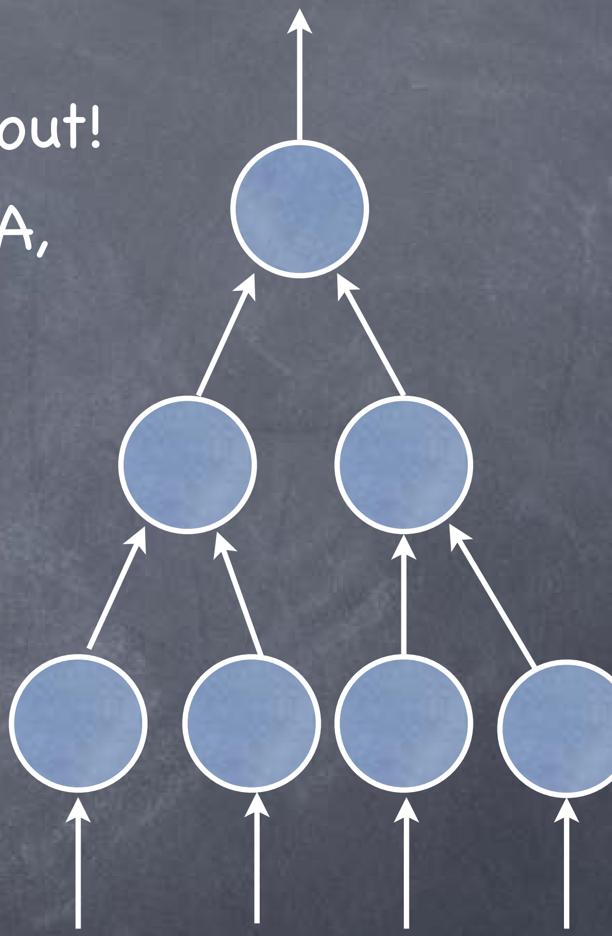

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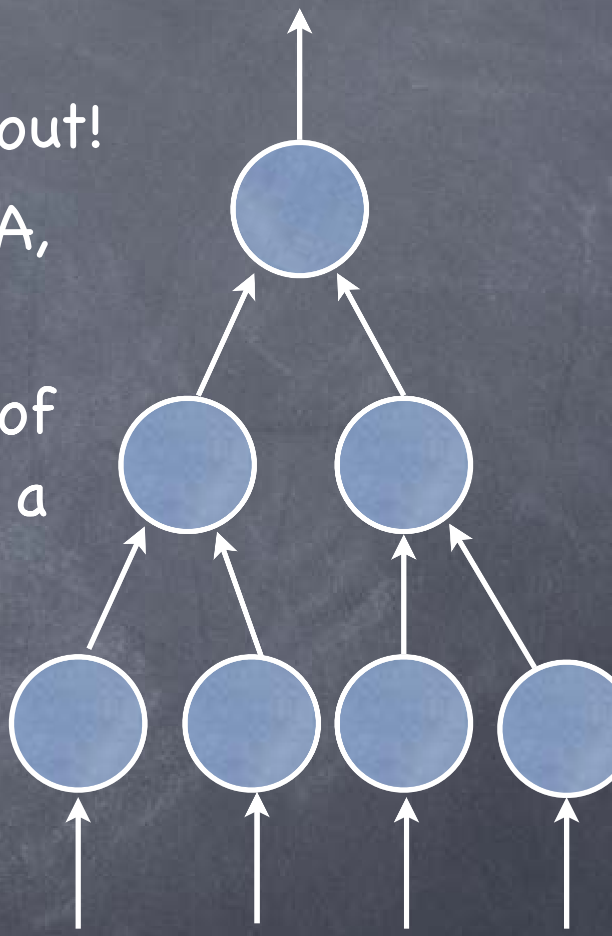

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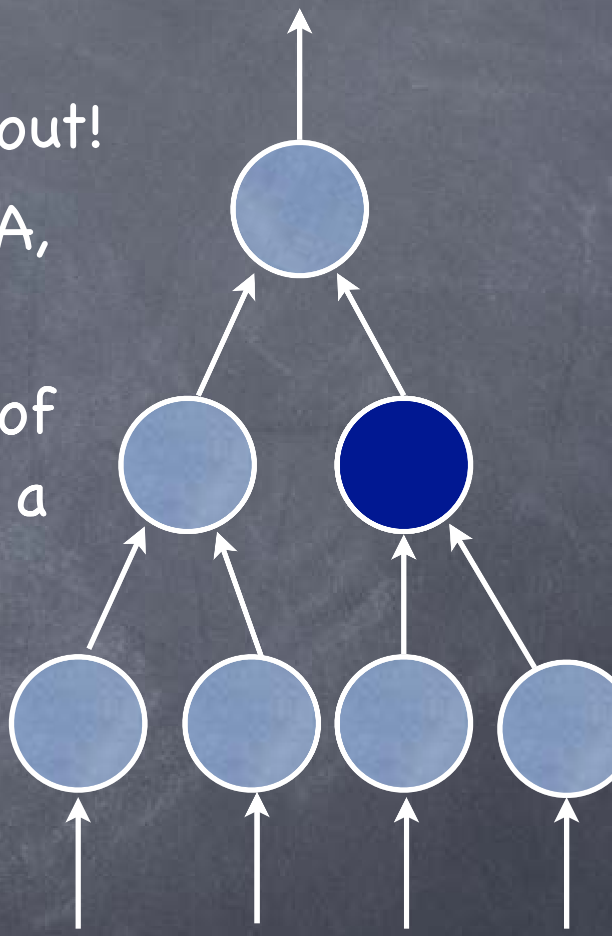

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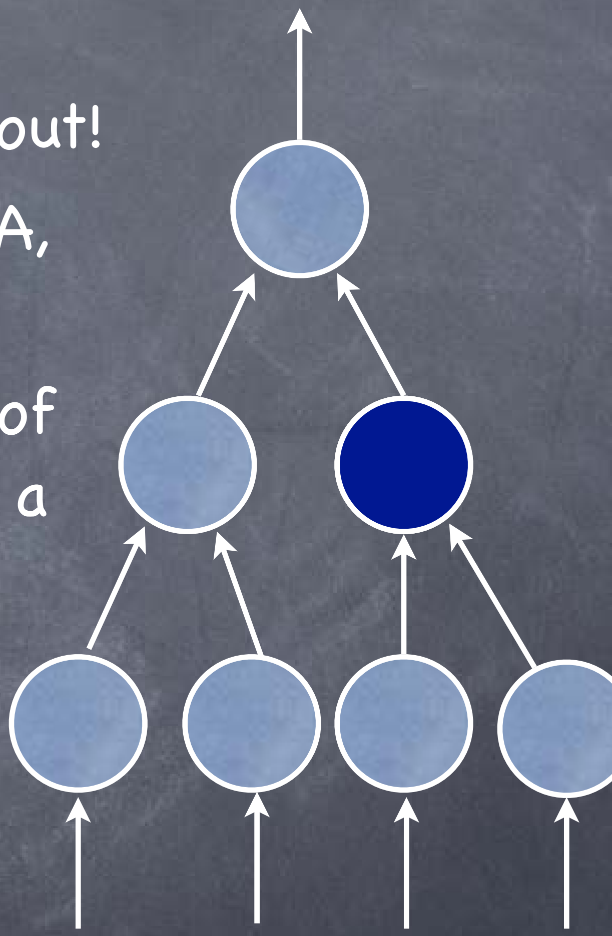

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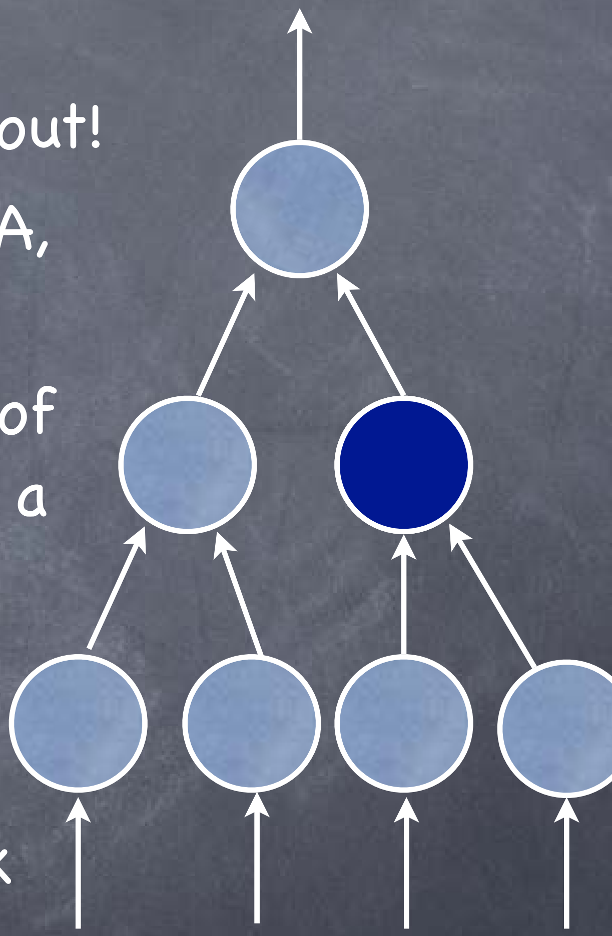

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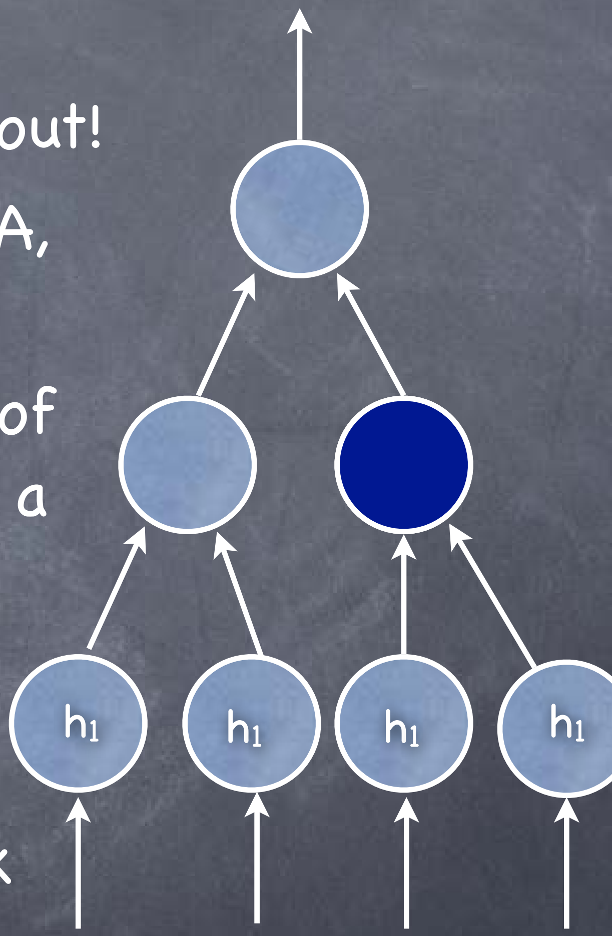

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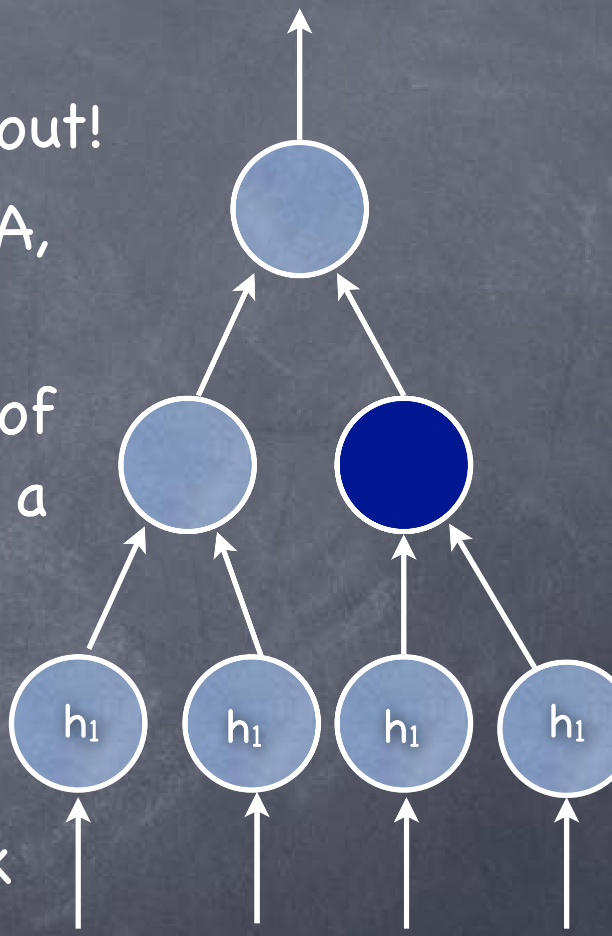

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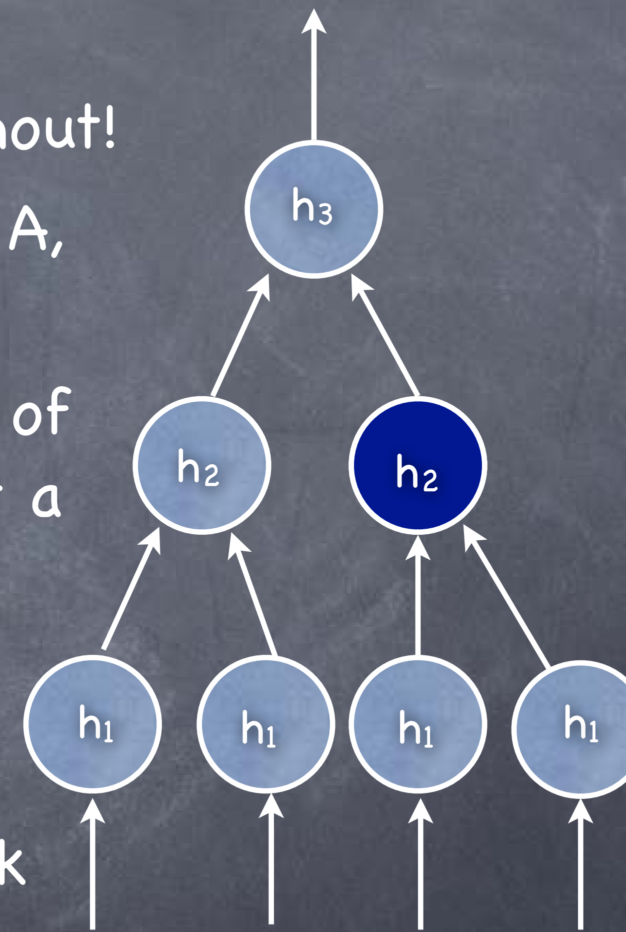

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- Current practice: much less paranoid; faith on efficient, ad hoc (and unkeyed) constructions (though increasingly under attack)

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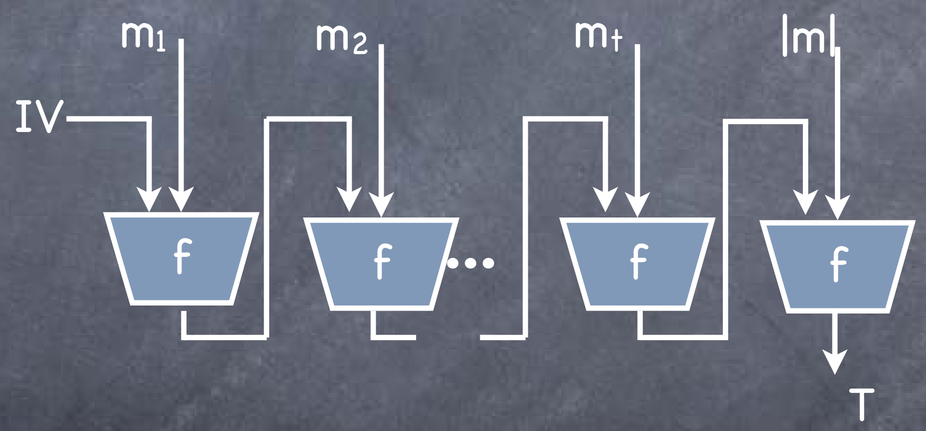

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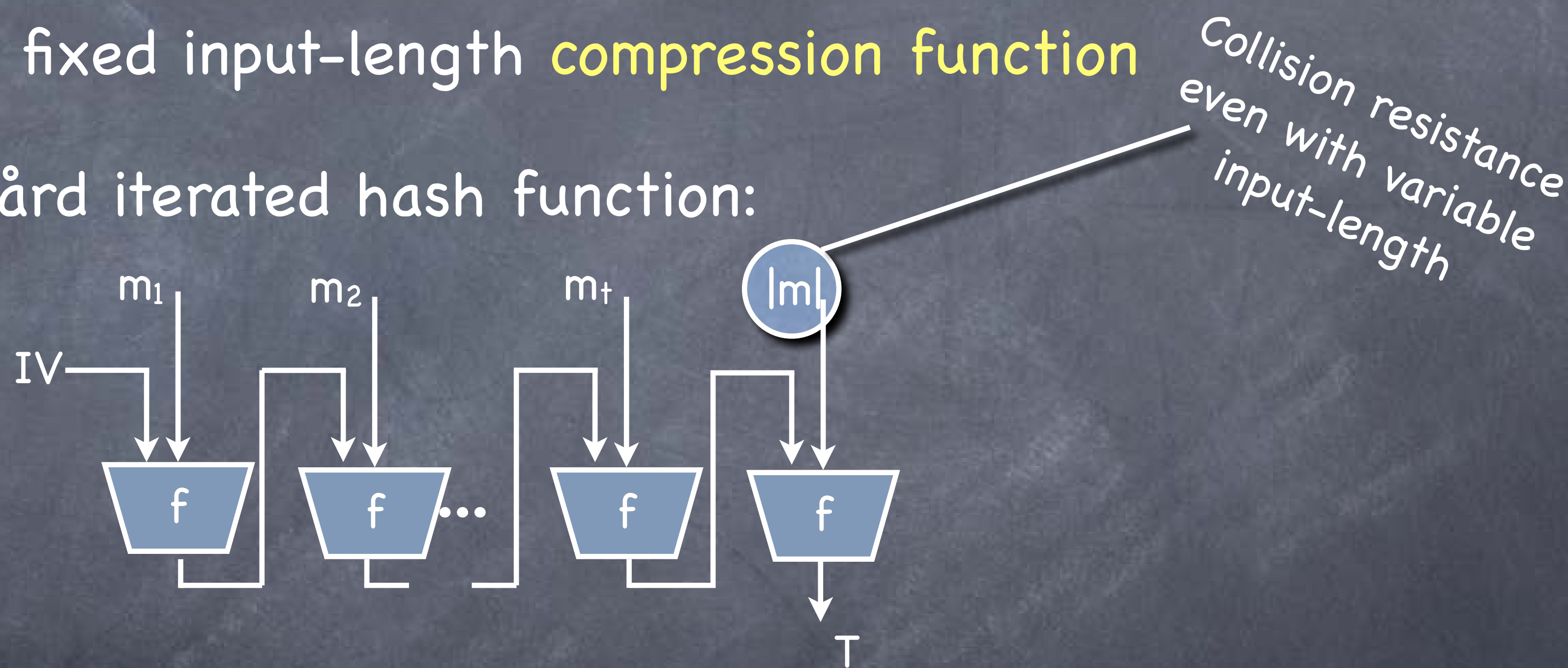

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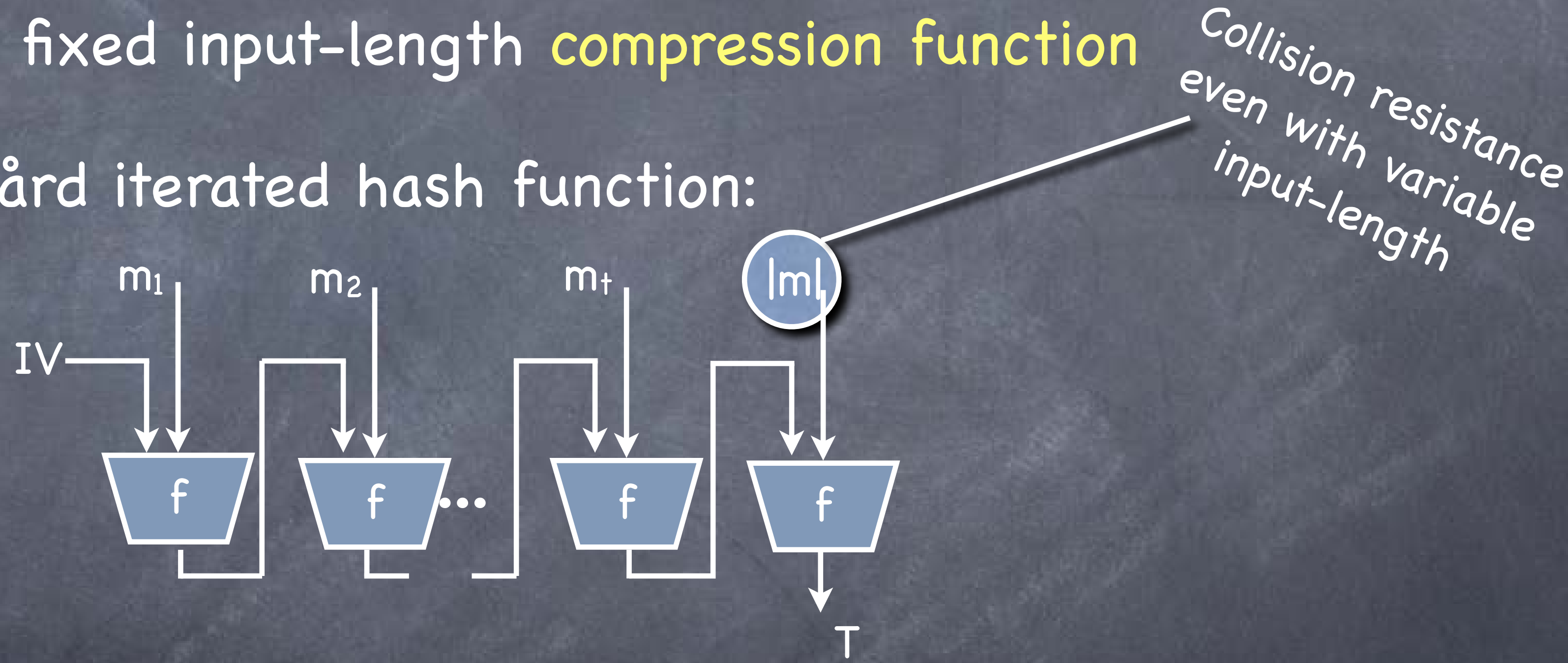

- If f collision resistant (not as "keyed" hash, but "concretely"), then so is the Merkle-Damgård iterated hash-function (for any IV)

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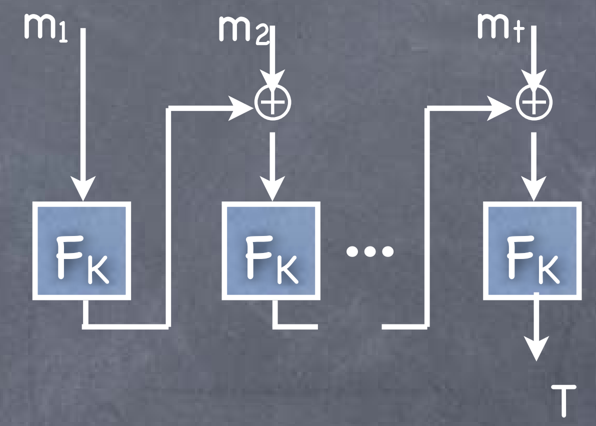

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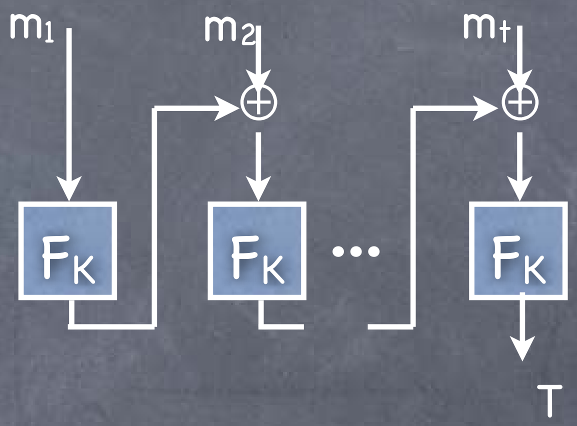

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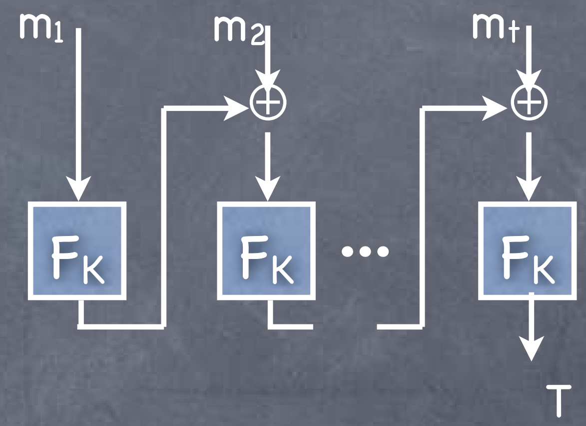

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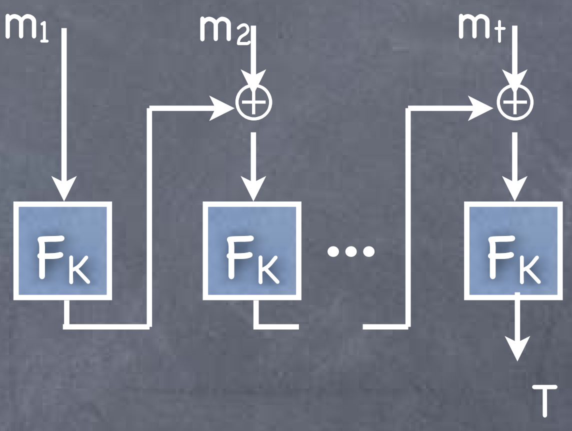

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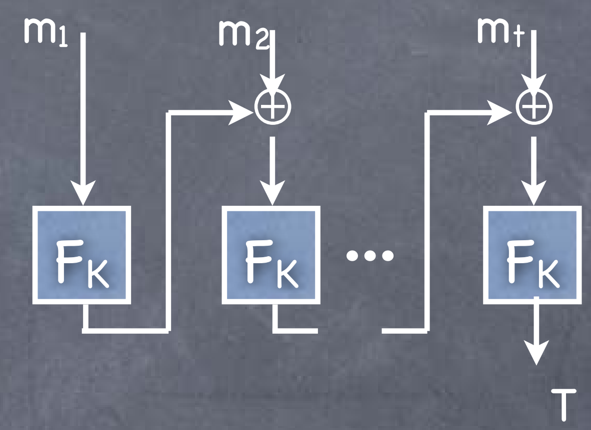

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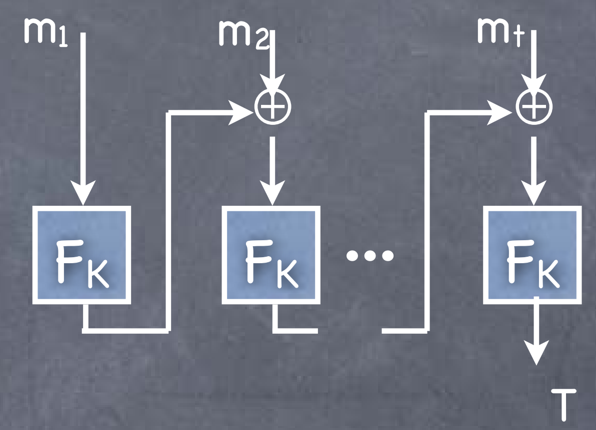

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- Making CBC-MAC variable input-length (can be proven secure):
  - Derive K as $F_{K'}(t)$, where t is the number of blocks
  - Or, Use first block to specify number of blocks
  - Or, output not the last tag T, but $F_{K'}(T)$, where K' is an independent key (EMAC)
  - Or, XOR last message block with another key K' (CMAC)

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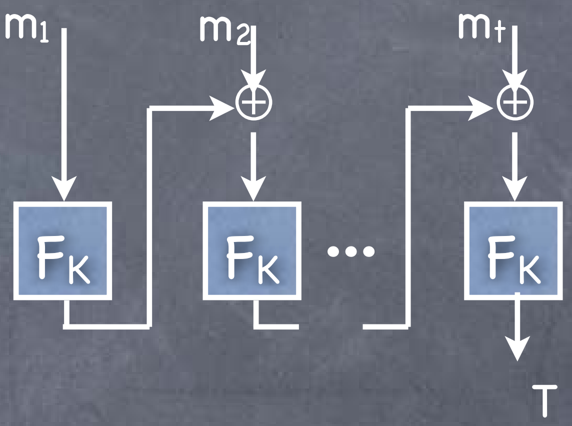

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  - $MAC_{K,h}^*(M) = PRF_K(h(M))$ where $h \leftarrow \mathcal{H}$, and $\mathcal{H}$ a 2-UHF

h(M) not revealed

- A proper MAC must work on inputs of variable length
- Making CBC-MAC variable input-length (can be proven secure):
  - Derive K as $F_{K'}(t)$, where t is the number of blocks
  - Or, Use first block to specify number of blocks
  - Or, output not the last tag T, but $F_{K'}(T)$, where K' is an independent key (EMAC)
  - Or, XOR last message block with another key K' (CMAC)
- Leave variable input-lengths to the hash?

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  - Weak-CRHFs can be based on OWF. Can be more efficiently constructed from fixed input-length MACs.

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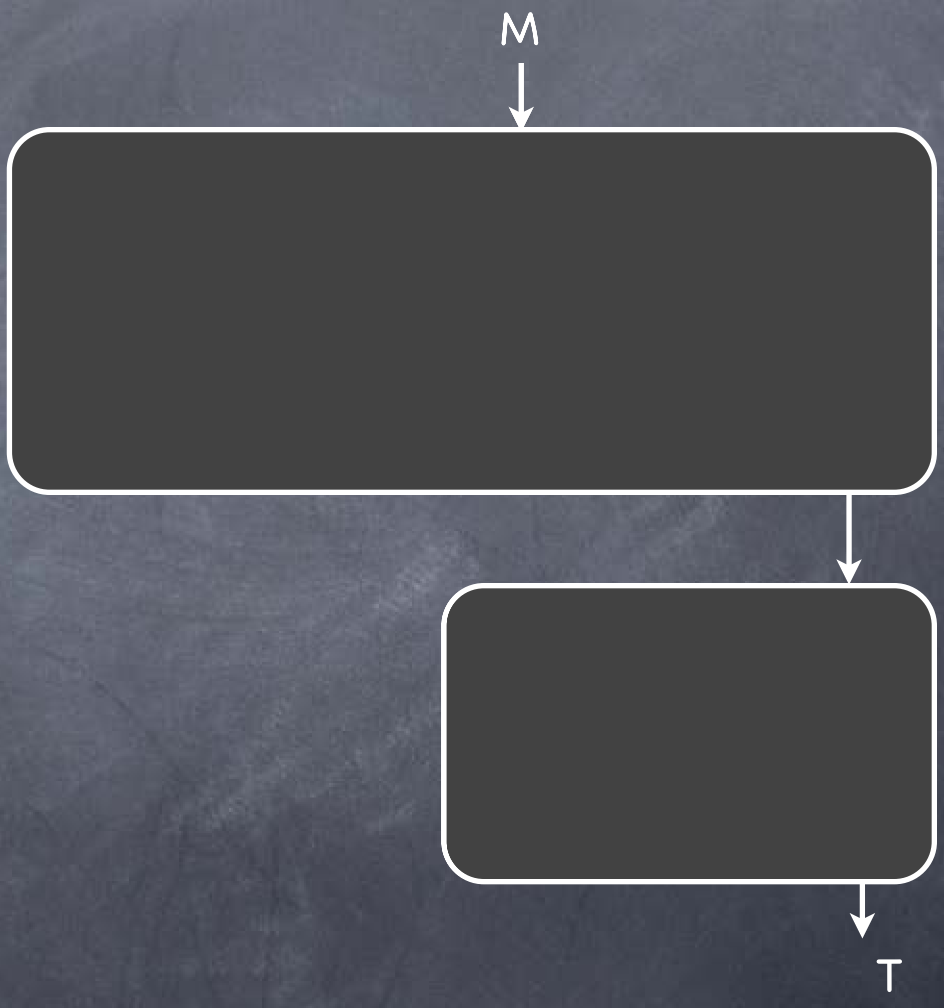
HMAC



HMAC

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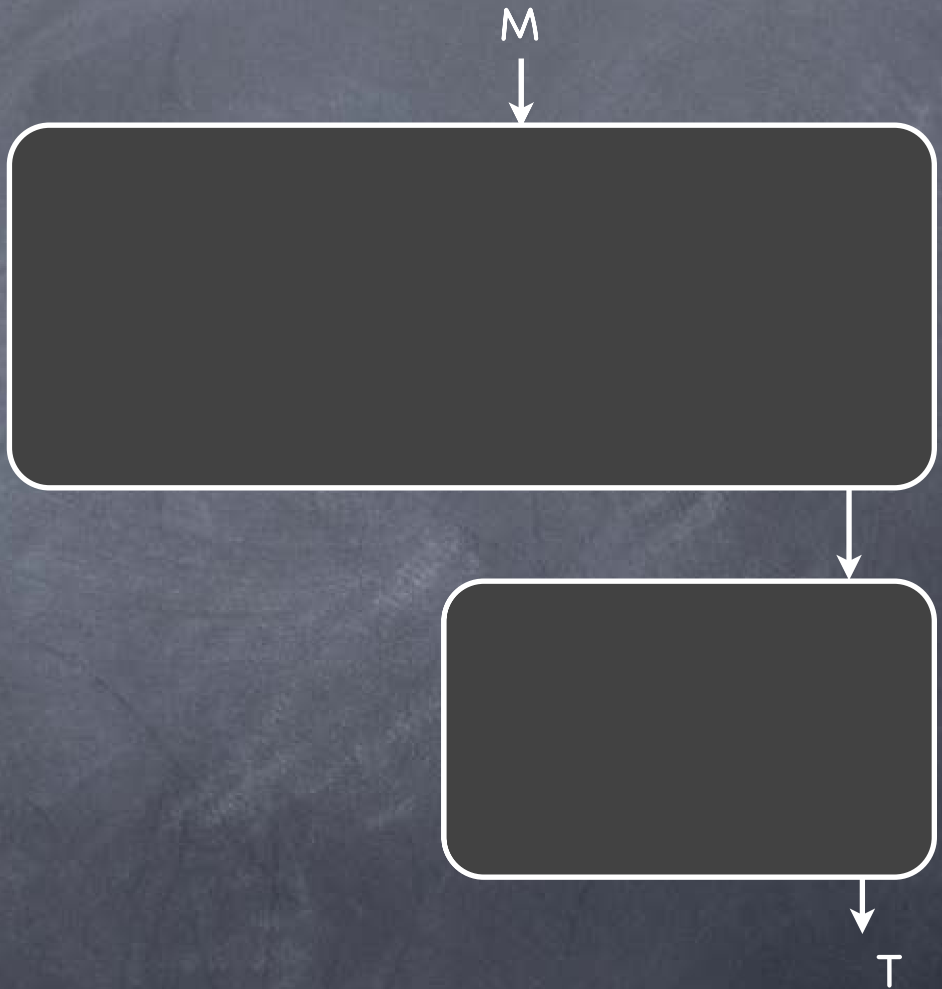

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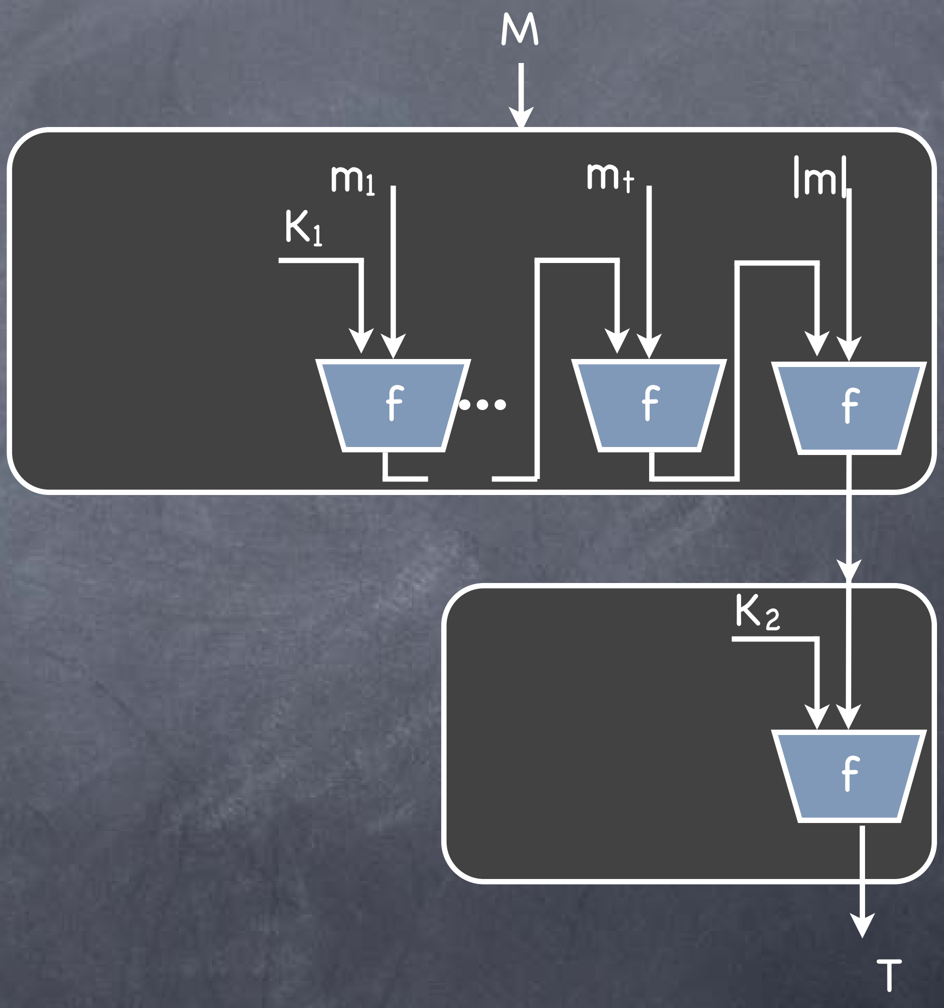

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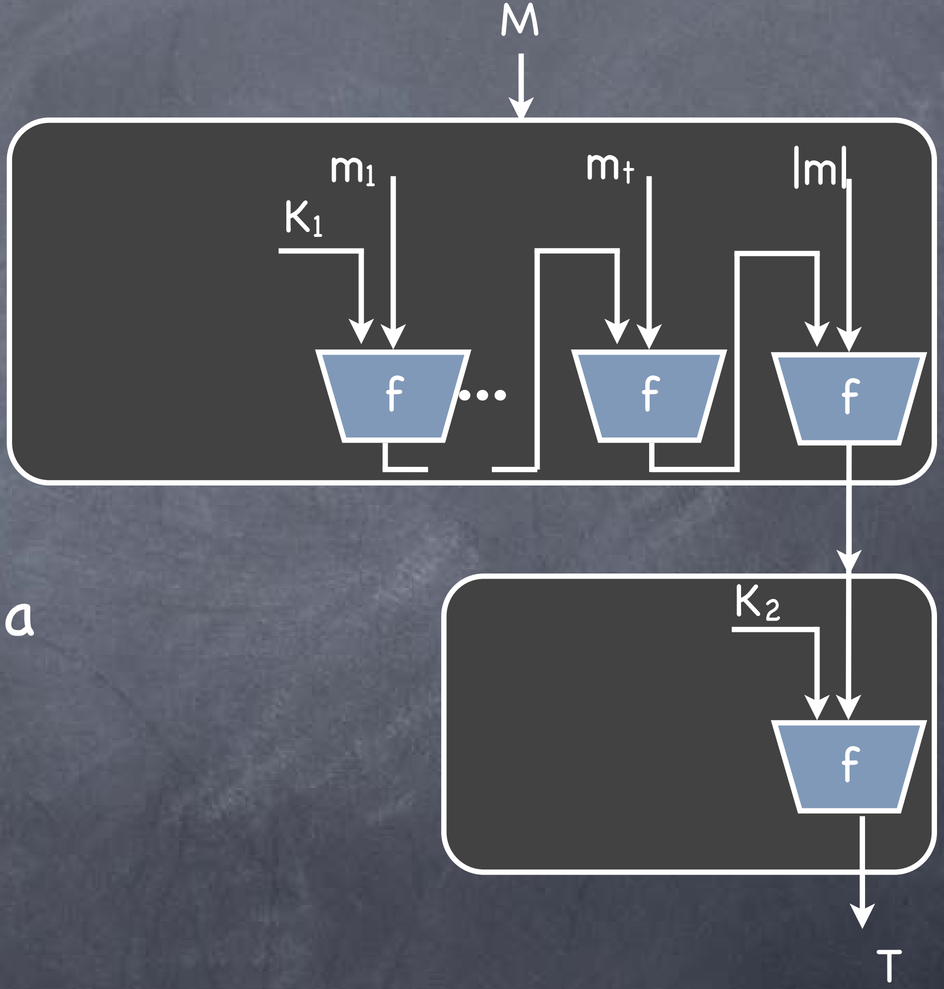

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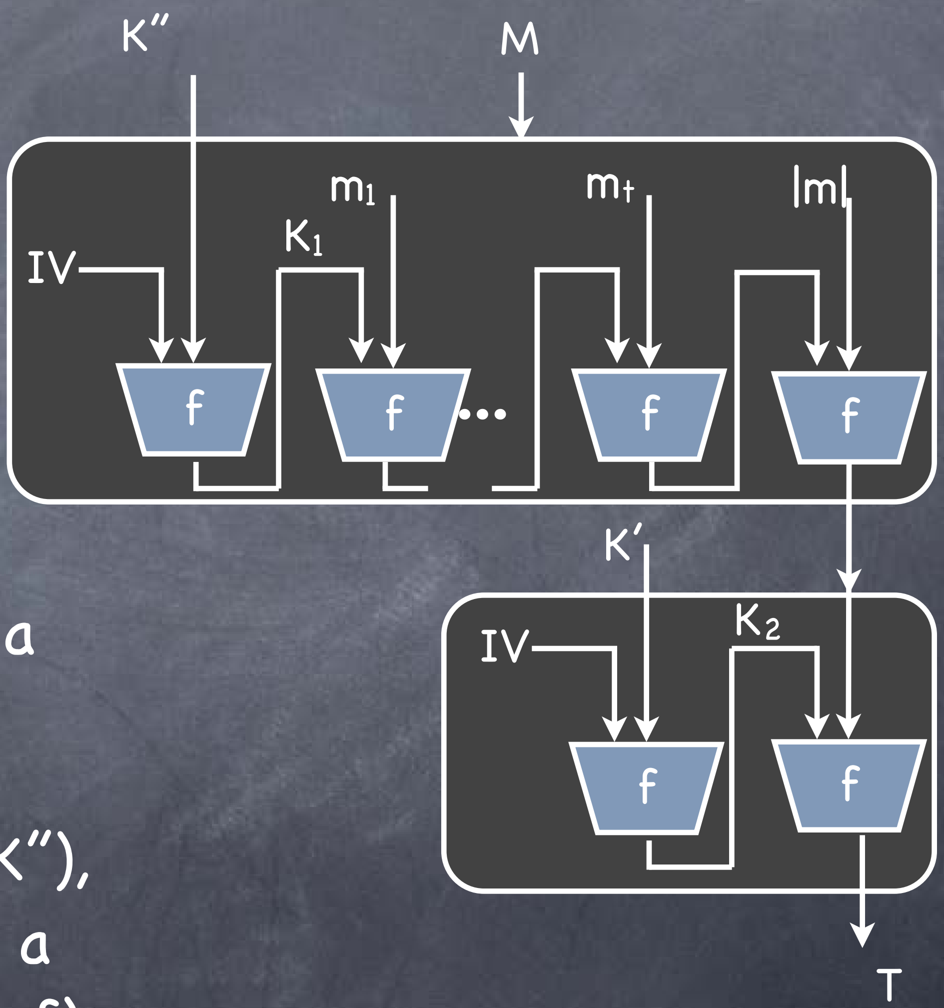
  - In HMAC (K_1,K_2) derived from (K′,K″), in turn heuristically derived from a single key K. If f is a (weak kind of) PRF K_1, K_2 can be considered independent



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    - (That attack can be fixed by preventing extension: prefix-free encoding)
  - Other suggestions like SHA1(M||K), SHA1(K||M||K) all turned out to be flawed too

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