QUANTIFIERS

- "For all" universal quantifier $\forall$
- "There exists" existential quantifier $\exists$

Examples
- All natural numbers are positive $\forall n \in \mathbb{N} : n \geq 0$
- All elephants have a trunk $(\forall \text{ elephants } x)(x \text{ has a trunk})$
- Some natural number equals 3 $\exists n \in \mathbb{N} : n = 3$
- Some countries do not have a sea border
  $(\exists \text{ country } x)(x \text{ has no sea border})$

Negation
- There is a natural number that is negative
- $\exists n \in \mathbb{N} : n < 0$
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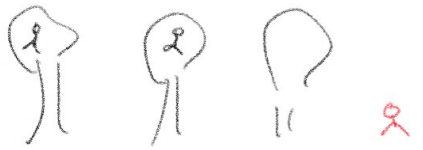
- There is no natural number equal to 3
  = All natural numbers are different from 3
  $\forall n \in \mathbb{N} : n \neq 3$

Combining quantifiers

· Every monkey climbs a tree
$(\forall \text{ monkey } m)(\exists \text{ tree } t)(m \text{ climbs } t)$



negation: $(\exists \text{ monkey } m)(\neg \exists \text{ tree } t)$...

· $(\exists \text{ tree } t)(\forall \text{ monkey } m)(m \text{ climbs } t)$
= All monkeys climb the same tree

$\neg(\exists \text{ tree } t)(\forall \text{ monkey } m)$...

· $(\forall \text{ tree } t)(\exists \text{ monkey } m)(m \text{ climbs } t)$

$(\exists \text{ tree } t)(\neg \exists \text{ monkey } m)$

· $(\exists \text{ monkey } m)(\forall \text{ tree } t)(m \text{ climbs } t)$

$(\neg \exists \text{ monkey } m)(\forall \text{ tree } t)(m \text{ climbs } t)$