# Fault Localization & Relevance Analysis

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**Definition 1** (Execution)**.** *Let $\pi$ be an error trace of length $n$. An execution of $\pi$ is a sequence of states $s_0, s_1 ... s_n$ such that $s_i, s_{i+1} \models T$, where $T$ is the transition formula of $\pi[i]$.*
*Let $\epsilon$ represent the set of all possible executions of the error trace.*

**Definition 2** (Blocking Execution)**.** *An execution of a trace $\pi$ of size $n$ is called a blocking execution if there exists a sequence of states $s_0, s_1 ... s_j$ where $i < j \leq n$ such that $s_i, s_{i+1} \models T[i]$, where $T[i]$ is the transition formula of $\pi[i]$ and there exits an assume statement in the trace $\pi$ at position $j$ such that $s_j \not\models guard(\pi[j])$.*

**Definition 3** (Relevancy of an assignment statement)**.** *Let $\beta$ represent the set of all blocking executions of a trace $\pi$. Let there be an assignment statement of the form $x := t$ at position $i$. Let $\pi'$ represent the trace that we get after replacing $\pi[i]$ with a havoc statement of the form $havoc(x)$ and let $\beta'$ represent the set of all blocking executions for $\pi'$.*
*We say that the assignment statement $\pi[i]$ is relevant if the trace after the replacement has strictly more blocked executions than the trace before the replacement, i.e if $\beta \subsetneq \beta'$.*

**Theorem 1** (Relevancy of an assignment statement)**.** *Let $\pi$ be an error trace of length $n$ and $\pi[i]$ be an assignment statement at position $i$ having the form $x := t$, where $x$ is a variable and $t$ is an expression. Let $P$ and $Q$ be two predicates where $P = \neg WP(False; \pi[i,n]) \bigcap SP(True; \pi[1, i-1])$ and $Q = \neg WP(False; \pi[i+1, n])$. The statement $\pi[i]$ is relevant iff:*

$$P \not\Rightarrow WP(Q, havoc(x))$$

*Proof.* Let $\pi'$ be the trace where the assignment statement $\pi[i]$ is replaced by a havoc statement.
"$\Rightarrow$"
If the assignment statement $\pi[i]$ is relevant then:

$$P \not\Rightarrow WP(Q, havoc(x))$$

The relevancy of the assignment statement $\pi[i]$ implies that the trace $\pi'$ have strictly more blocking exections then $\pi$. This means that there exists an assume statement in the trace $\pi$ at position $j$, which is blocking more executions then before. Or we can say that there are more states $s_j$ for which the assume statement is blocking.
OR something something. □