

## prf.1 The Sequent Calculus

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sec While many **derivation** systems operate with arrangements of **sentences**, the sequent calculus operates with *sequents*. A sequent is an expression of the form

$$\varphi_1, \dots, \varphi_m \Rightarrow \psi_1, \dots, \psi_n,$$

that is a pair of sequences of **sentences**, separated by the sequent symbol  $\Rightarrow$ . Either sequence may be empty. A **derivation** in the sequent calculus is a tree of sequents, where the topmost sequents are of a special form (they are called “initial sequents” or “axioms”) and every other sequent follows from the sequents immediately above it by one of the rules of inference. The rules of inference either manipulate the **sentences** in the sequents (adding, removing, or rearranging them on either the left or the right), or they introduce a complex **formula** in the conclusion of the rule. For instance, the  $\wedge L$  rule allows the inference from  $\varphi, \Gamma \Rightarrow \Delta$  to  $A \wedge \psi, \Gamma \Rightarrow \Delta$ , and the  $\rightarrow R$  allows the inference from  $\varphi, \Gamma \Rightarrow \Delta, \psi$  to  $\Gamma \Rightarrow \Delta, \varphi \rightarrow \psi$ , for any  $\Gamma$ ,  $\Delta$ ,  $\varphi$ , and  $\psi$ . (In particular,  $\Gamma$  and  $\Delta$  may be empty.)

The  $\vdash$  relation based on the sequent calculus is defined as follows:  $\Gamma \vdash \varphi$  iff there is some sequence  $\Gamma_0$  such that every  $\varphi$  in  $\Gamma_0$  is in  $\Gamma$  and there is a **derivation** with the sequent  $\Gamma_0 \Rightarrow \varphi$  at its root.  $\varphi$  is a theorem in the sequent calculus if the sequent  $\Rightarrow \varphi$  has a **derivation**. For instance, here is a **derivation** that shows that  $\vdash (\varphi \wedge \psi) \rightarrow \varphi$ :

$$\frac{\frac{\varphi \Rightarrow \varphi}{\varphi \wedge \psi \Rightarrow \varphi} \wedge L}{\Rightarrow (\varphi \wedge \psi) \rightarrow \varphi} \rightarrow R$$

A set  $\Gamma$  is inconsistent in the sequent calculus if there is a **derivation** of  $\Gamma_0 \Rightarrow$  (where every  $\varphi \in \Gamma_0$  is in  $\Gamma$  and the right side of the sequent is empty). Using the rule WR, any **sentence** can be **derived** from an inconsistent set.

The sequent calculus was invented in the 1930s by Gerhard Gentzen. Because of its systematic and symmetric design, it is a very useful formalism for developing a theory of **derivations**. It is relatively easy to find **derivations** in the sequent calculus, but these **derivations** are often hard to read and their connection to proofs are sometimes not easy to see. It has proved to be a very elegant approach to **derivation** systems, however, and many logics have sequent calculus systems.

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## Bibliography