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On the Order-consistent Topology of Complete and Uncomplete Lattices

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Summary. This paper is a continuation of the formalisation of [9] pp. 108–109. Order-consistent and upper topologies are defined. The theorem that the Scott and the upper topologies are order-consistent is proved. Remark 1.4 and example 1.5(2) are generalized for proving this theorem.

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The articles [15], [7], [20], [21], [5], [8], [6], [18], [1], [13], [12], [23], [19], [2], [3], [14], [10], [16], [11], [22], [17], and [4] provide the notation and terminology for this paper.

Let T be a non empty FR-structure. We say that T is upper if and only if:

(Def. 1) $\{(\downarrow x)^{\mathrm{c}} : x$ ranges over elements of $T\}$ is a prebasis of T.

One can check that there exists a top-lattice which is Scott, up-complete, and strict.

Let T be a topological space-like non empty reflexive FR-structure. We say that T is order consistent if and only if the condition (Def. 2) is satisfied.

(Def. 2) Let x be an element of T. Then

(i) $\downarrow x = \overline{\{x\}}$, and

(ii) for every eventually-directed net N in T such that $x = \sup N$ and for every neighbourhood V of x holds N is eventually in V.

Let us note that every non empty reflexive topological space-like FR-structure which is trivial is also upper.

Let us mention that there exists a top-lattice which is upper, trivial, up-complete, and strict.

One can prove the following propositions:

(1) For every upper up-complete non empty top-poset T and for every subset A of T such that A is open holds A is upper.

(2) For every up-complete non empty top-poset T such that T is upper holds T is order consistent.

(7)[1] For every up-complete non empty reflexive transitive antisymmetric relational structure R holds there exists a topological augmentation of R which is Scott.

(8) Let R be an up-complete non empty poset and T be a topological augmentation of R. If T is Scott, then T is correct.

[1] The propositions (3)–(6) have been removed.

Let R be an up-complete non empty reflexive transitive antisymmetric relational structure. Note that every topological augmentation of R which is Scott is also correct.

Let R be an up-complete non empty reflexive transitive antisymmetric relational structure. Observe that there exists a topological augmentation of R which is Scott and correct.

We now state several propositions:

(9) Let T be a Scott up-complete non empty reflexive transitive antisymmetric FR-structure and x be an element of T. Then $\overline{\{x\}} = {\downarrow}x$.

(10) Every up-complete Scott non empty top-poset is order consistent.

(11) Let R be an inf-complete semilattice, Z be a net in R, and D be a subset of R. Suppose $D = \{\bigsqcap_R\{Z(k); k$ ranges over elements of Z: $k \geq j\} : j$ ranges over elements of $Z\}$. Then D is non empty and directed.

(12) Let R be an inf-complete semilattice, S be a subset of R, and a be an element of R. If $a \in S$, then $\bigsqcap_R S \leq a$.

(13) For every inf-complete semilattice R and for every monotone reflexive net N in R holds $\liminf N = \sup N$.

(14) Let R be an inf-complete semilattice and S be a subset of R. Then $S \in$ the topology of ConvergenceSpace(the Scott convergence of R) if and only if S is inaccessible and upper.

(15) Let R be an inf-complete up-complete semilattice and T be a topological augmentation of R. If the topology of $T = \sigma(R)$, then T is Scott.

Let R be an inf-complete up-complete semilattice. Note that there exists a topological augmentation of R which is strict, Scott, and correct.

The following two propositions are true:

(16) Let S be an up-complete inf-complete semilattice and T be a Scott topological augmentation of S. Then $\sigma(S) =$ the topology of T.

(17) Every Scott up-complete non empty reflexive transitive antisymmetric FR-structure is a T_0-space.

Let R be an up-complete non empty reflexive transitive antisymmetric relational structure. Note that every topological augmentation of R is up-complete.

One can prove the following propositions:

(18) Let R be an up-complete non empty reflexive transitive antisymmetric relational structure, T be a Scott topological augmentation of R, x be an element of T, and A be an upper subset of T. If $x \notin A$, then $({\downarrow}x)^{\mathrm{c}}$ is a neighbourhood of A.

(19) Let R be an up-complete non empty reflexive transitive antisymmetric FR-structure, T be a Scott topological augmentation of R, and S be an upper subset of T. Then there exists a family F of subsets of T such that $S = \bigcap F$ and for every subset X of T such that $X \in F$ holds X is a neighbourhood of S.

(20) Let T be a Scott up-complete non empty reflexive transitive antisymmetric FR-structure and S be a subset of T. Then S is open if and only if S is upper and property(S).

(21) Let R be an up-complete non empty reflexive transitive antisymmetric FR-structure, S be a non empty directed subset of R, and a be an element of R. If $a \in S$, then $a \leq \bigsqcup_R S$.

Let T be an up-complete non empty reflexive transitive antisymmetric FR-structure. One can check that every subset of T which is lower is also property(S).

Next we state three propositions:

(22) For every finite up-complete non empty poset T holds every subset of T is inaccessible.

(23) Let R be a complete connected lattice, T be a Scott topological augmentation of R, and x be an element of T. Then $(\downarrow x)^{\rm c}$ is open.

(24) Let R be a complete connected lattice, T be a Scott topological augmentation of R, and S be a subset of T. Then S is open if and only if one of the following conditions is satisfied:

(i) $S =$ the carrier of T, or

(ii) $S \in \{(\downarrow x)^{\rm c} : x$ ranges over elements of $T\}$.

Let R be an up-complete non empty poset. Note that there exists a correct topological augmentation of R which is order consistent.

Let us mention that there exists a top-lattice which is order consistent and complete.

One can prove the following propositions:

(25) Let R be a non empty FR-structure and A be a subset of R. Suppose that for every element x of R holds $\downarrow x = \overline{\{x\}}$. If A is open, then A is upper.

(26) Let R be a non empty FR-structure and A be a subset of R. Suppose that for every element x of R holds $\downarrow x = \overline{\{x\}}$. Let A be a subset of R. If A is closed, then A is lower.

(27) For every up-complete inf-complete lattice T and for every net N in T and for every element i of N holds $\liminf(N{\restriction}i) = \liminf N$.

Let S be a non empty 1-sorted structure, let R be a non empty relational structure, and let f be a function from the carrier of R into the carrier of S. The functor $R * f$ yields a strict non empty net structure over S and is defined as follows:

(Def. 3) The relational structure of $R * f =$ the relational structure of R and the mapping of $R * f = f$.

Let S be a non empty 1-sorted structure, let R be a non empty transitive relational structure, and let f be a function from the carrier of R into the carrier of S. Observe that $R * f$ is transitive.

Let S be a non empty 1-sorted structure, let R be a non empty directed relational structure, and let f be a function from the carrier of R into the carrier of S. Note that $R * f$ is directed.

Let R be a non empty relational structure and let N be a prenet over R. The functor $\inf\_{\rm net} N$ yielding a strict prenet over R is defined by:

(Def. 4) There exists a map f from N into R such that $\inf\_{\rm net} N = N * f$ and for every element i of N holds $f(i) = \bigsqcap_R \{N(k); k$ ranges over elements of N: $k \geq i\}$.

Let R be a non empty relational structure and let N be a net in R. One can check that $\inf\_{\rm net} N$ is transitive.

Let R be a non empty relational structure and let N be a net in R. Observe that $\inf\_{\rm net} N$ is directed.

Let R be an inf-complete non empty reflexive antisymmetric relational structure and let N be a net in R. One can check that $\inf\_{\rm net} N$ is monotone.

Let R be an inf-complete non empty reflexive antisymmetric relational structure and let N be a net in R. Observe that $\inf\_{\rm net} N$ is eventually-directed.

Next we state several propositions:

(28) Let R be a non empty relational structure and N be a net in R. Then rng(the mapping of $\inf\_{\rm net} N) = \{\bigsqcap_R \{N(i); i$ ranges over elements of N: $i \geq j\} : j$ ranges over elements of $N\}$.

(29) For every up-complete inf-complete lattice R and for every net N in R holds $\sup \inf\_{\rm net} N = \liminf N$.

(30) For every up-complete inf-complete lattice R and for every net N in R and for every element i of N holds $\sup \inf\_{\rm net} N = \liminf(N{\restriction}i)$.

(31) Let R be an inf-complete semilattice, N be a net in R, and V be an upper subset of R. If $\inf\_{\rm net} N$ is eventually in V, then N is eventually in V.

(32) Let R be an inf-complete semilattice, N be a net in R, and V be a lower subset of R. If N is eventually in V, then $\inf\_\mathrm{net} N$ is eventually in V.

(33) Let R be an order consistent up-complete inf-complete non empty top-lattice, N be a net in R, and x be an element of R. If $x \leq \liminf N$, then x is a cluster point of N.

(34) Let R be an order consistent up-complete inf-complete non empty top-lattice, N be an eventually-directed net in R, and x be an element of R. Then $x \leq \liminf N$ if and only if x is a cluster point of N.

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