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A TOTALLY BOUNDED, COMPLETE UNIFORM SPACE IS COMPACT

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Let X be a set and U a uniformity on X. We will show that if (X, U) is totally bounded, every net in X has a Cauchy subnet. For each $d \in U$, let $S_d^1, \cdots, S_d^n$ be a finite covering of X by d-spheres. Let T_d be the topology on X having $S_d^1, \cdots, S_d^n$ as its subbasis. Clearly the space (X, T_d) is compact. Therefore, $Y = \prod_{d \in U} (X, T_d)$ is compact.

Now, let (p_i) be a net in X. Then $\Delta \circ (p_i)$ is a net in Y, where $\Delta: X \to Y$ is the diagonal. By compactness, there exists a convergent subnet, (q_j), of $\Delta \circ (p_i)$. Then $\Delta^{-1} \circ (q_j)$ is a subnet of (p_i) which is clearly Cauchy.

Thus, if (X, U) is also complete, every net in X has a convergent subnet, so (X, U) is compact.

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