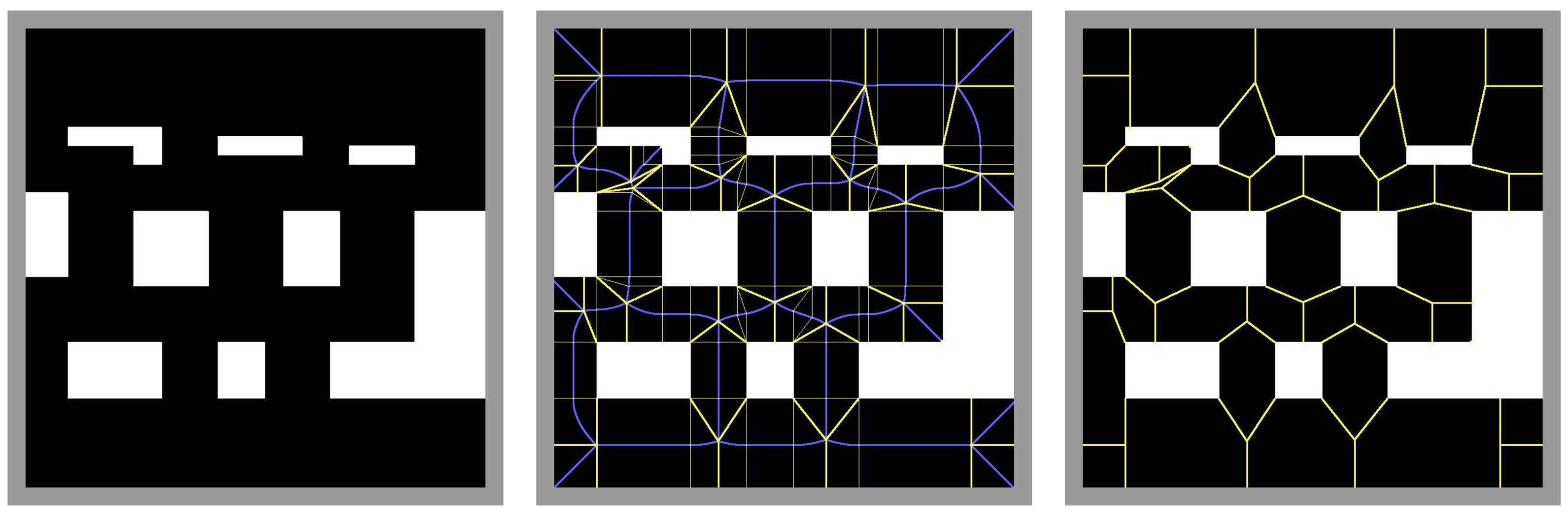
Realistic Crowd Simulation with Density-Based Path Planning

If all characters in a virtual crowd follow the shortest path, traffic jams will occur in popular regions. Other regions will remain unused. To solve this, we store **crowd density information** in a navigation mesh to guide a **density-based path planning algorithm**. In our framework, characters are willing to take detours through less crowded regions. Combined with replanning, this leads to an efficient and realistic crowd flow.

Method

The **Explicit Corridor Map** navigation mesh subdivides an environment into non-overlapping walkable regions.



Environment | Explicit Corridor Map | **Density regions**

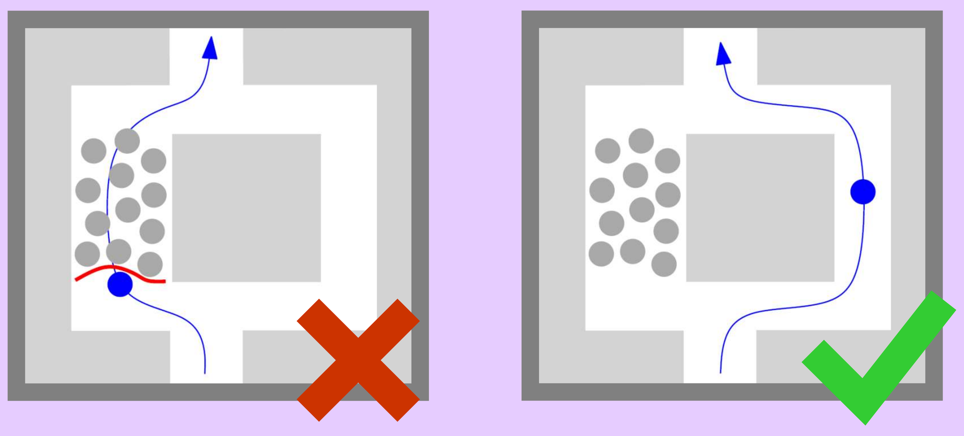
As a crowd moves through the environment, we keep track of the crowd density in each region.

Crowd density: the fraction of a region that is currently occupied by moving characters.

Observed in real life: **When the density is high, people walk more slowly.**

Characters can compute their **expected walking speed** in a region, and thus the **expected delay**.

Look for a **fast path**: a short path with little expected delay due to density-based slowdowns.



We use A* search with time-based costs. The sensitivity to delay is intuitive to control:

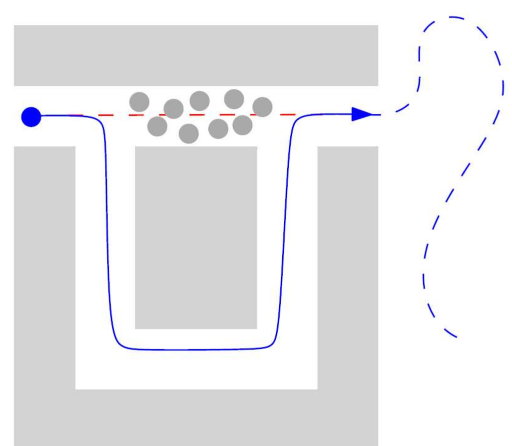
$$cost(edge) = time_{min}(edge) + w \cdot delay(edge)$$

As densities change over time, characters must **re-evaluate** their paths regularly.

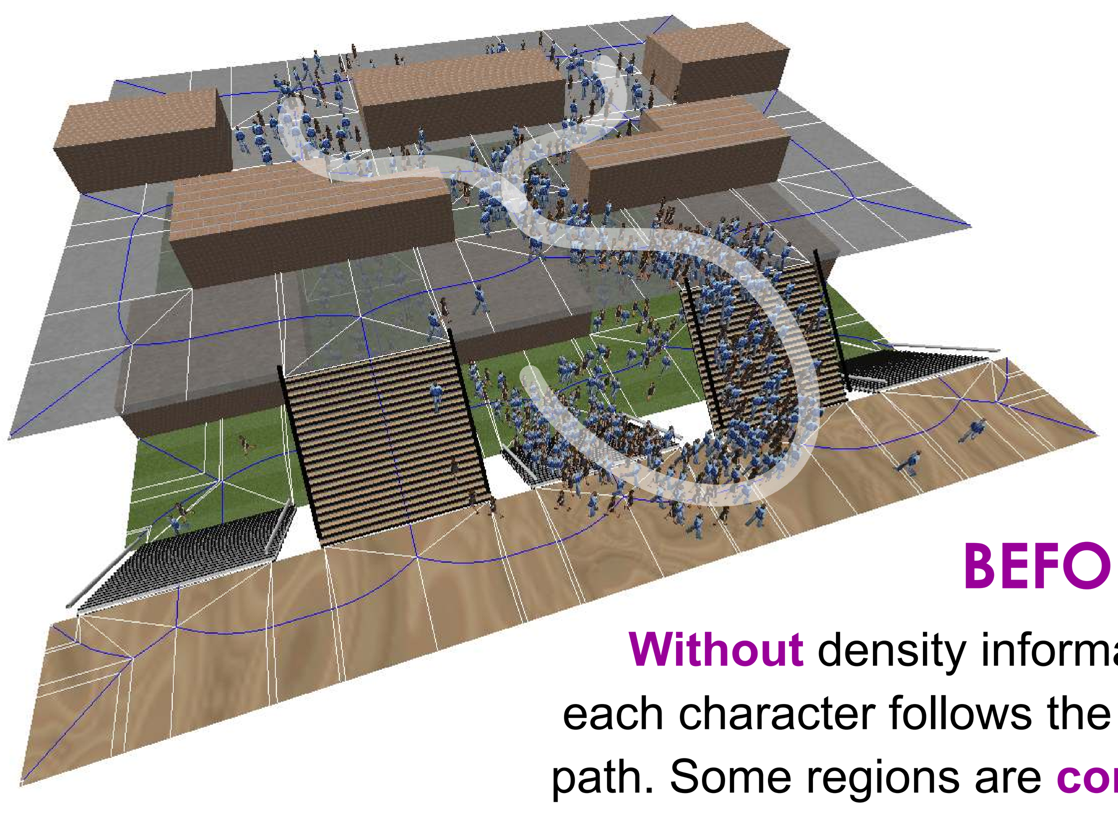
In the real world, people are only aware of the density in their **local** neighborhood.

Our characters can only “see” density information within a **viewing distance**. For other areas, they assume that there will be no delay.

When replanning a path, a character can **re-use invisible parts** of its previous path, without loss of optimality.

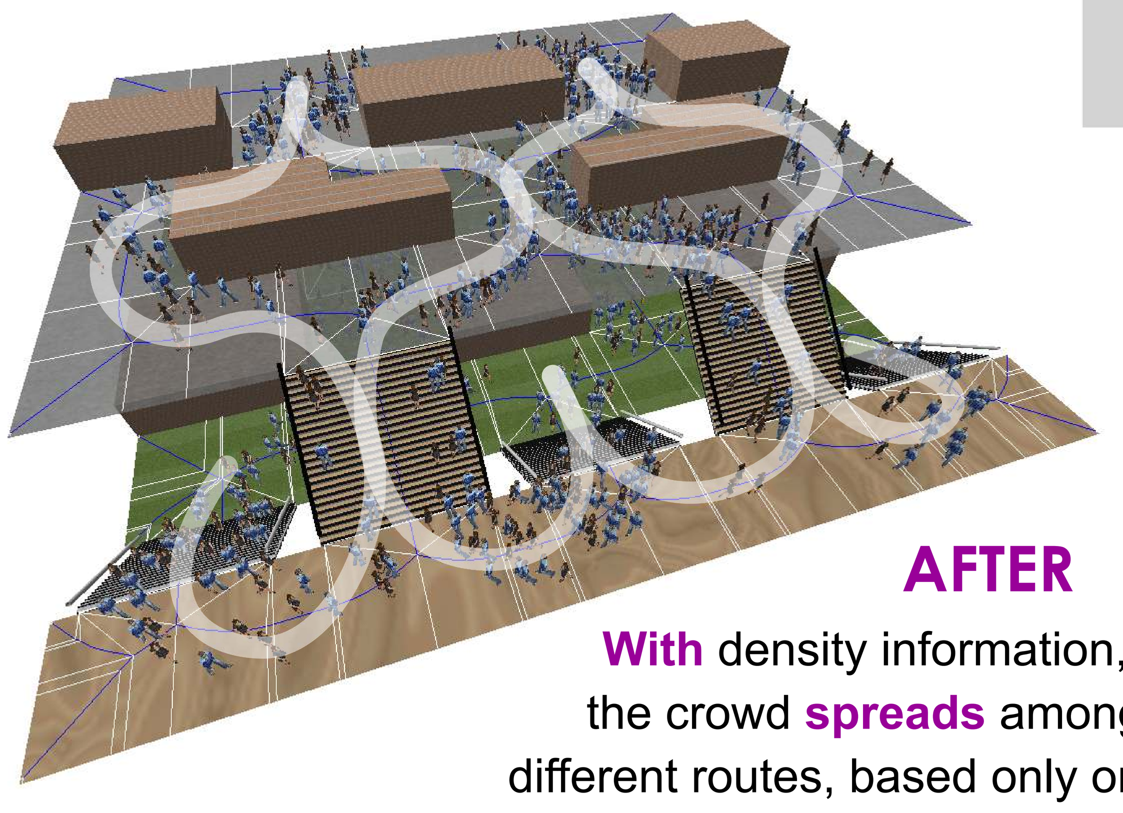


Results



BEFORE

Without density information, each character follows the shortest path. Some regions are **congested**; other regions are underutilized.



AFTER

With density information, the crowd **spreads** among different routes, based only on the characters’ individual choices.

With multi-threading techniques, we can simulate **tens of thousands** of walking and replanning characters in real-time.

Partial replanning can reduce the planning time, allowing more replanning without losing real-time performance.

More information

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To learn more about our crowd simulation framework, visit http://people.cs.uu.nl/roland/

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