from anchor nodes to ordinary nodes. This is done by passing “heading” information from one node to another. An example of propagation of heading information between nodes is given in [8].

By heading is meant the angle between the $x$-axis of the node’s local coordinate system and the $y$-axis of the global coordinate system measured in counterclockwise direction from the $x$-axis of the node’s local coordinate system. For example, $\phi_i$ is the heading of $i$ in Figure 5. Once node $i$ passes the information $\phi_i$ and $\theta_{ij}$ to node $j$, then node $j$ can compute its heading by $\phi_j = \pi - (\theta_{ij} - \phi_i) + \theta_{ji}$. Once nodes know the global coordinate system, they can transform the bearing information measured in their local coordinate systems ($\theta_{ij}$ and $\theta_{ji}$) into bearing information in the global coordinate system ($\Theta_{ij}$ and $\Theta_{ji}$) as shown in Figure 6. We note that $\Theta_{ji} = \pi + \Theta_{ij} \pmod{2\pi}$.

2) Bearing Constraint: A bearing constraint between node $i$ and $j$ can be expressed as:

$$\angle[(p_j(t) - p_i(t)), e_x] = \Theta_{ij}$$ \hspace{1cm} (1)$$
$$\angle[(p_i(t) - p_j(t)), e_x] = \pi + \Theta_{ij} \pmod{2\pi}$$ \hspace{1cm} (2)

where $e_x$ is the unit vector along the $x$-axis of the global coordinate system, and $\angle[.]$ stands for the function that maps the two vectors in the argument to the angle between them, where the angle is measured in the counterclockwise direction from the second vector to the first vector in the argument. We will simply denote a bearing constraint between nodes $i$ and $j$ as $\angle(p(i), p(j)) = \Theta_{ij}$. 

Fig. 4. Local coordinate systems for node $i$ and node $j$ are shown with the axes $(x_i, y_i)$ and $(x_j, y_j)$, and bearing constraints for node $i$ and node $j$ are denoted by $\theta_{ij}$ and $\theta_{ji}$, respectively.