Sistem preporuka u aplikaciji Flora

1. Opis sistema preporuka

Pametni sistem preporuka implementiran u aplikaciji **Flora** temelji se na **item-based pristupu**. Sistem koristi podatke o prethodnim korisničkim narudžbama i analizira povezanost između proizvoda pomoću **ML.NET Matrix Factorization algoritma**.

- Kada korisnik kupi određeni proizvod (npr. buket ruža), sistem računa sličnost tog proizvoda sa drugim proizvodima koje su kupovali i drugi korisnici.
- Sistem predlaže **Top N proizvoda** s najvećim sličnostima (npr. aranžmane ili bukete sličnog tipa).
- Ako korisnik nema narudžbi, sistem vraća **featured ili new proizvode**.
- Algoritam se **dinamički uči** – kako raste broj narudžbi, preporuke postaju preciznije.

Time aplikacija korisnicima olakšava izbor i povećava angažman i zadovoljstvo.

2. Putanja i kod glavne logike servisa sistema preporuka

Putanja: FloraApp_RS2\Flora backend\Flora.Services\Services\RecommendationService

```
        public async Task<List<ProductResponse>> GetRecommendedProductsAsync(int productId, int
topN = 5)
        {
            try
            {
                if (_similarityMap.Count == 0)
                {
                    await RecalculateSimilarityMapAsync();
                }

                var recommendedProductIds = _similarityMap
                    .Where(kv => kv.Key.Item1 == productId)
                    .OrderByDescending(kv => kv.Value)
                    .Take(topN)
                    .Select(kv => kv.Key.Item2)
                    .ToList();

                using var context = _contextFactory.CreateDbContext();

                var products = await context.Products
                .Where(p => recommendedProductIds.Contains(p.Id) && p.IsAvailable && p.Active)
                .Include(p => p.Images)
                .Include(p => p.Category)
                .Include(p => p.Occasion)
                .ToListAsync();

            var result = recommendedProductIds
                .Select(id => products.FirstOrDefault(p => p.Id == id))
                .Where(p => p != null)
                .Select(p => new ProductResponse
                {
                    Id = p.Id,
                    Name = p.Name,
                    Description = p.Description,
                    Price = p.Price,
                    IsNew = p.IsNew,
                    IsFeatured = p.IsFeatured,
                    CategoryId = p.CategoryId,
                    CategoryName = p.Category?.Name,
                    OccasionId = p.OccasionId,
                    OccasionName = p.Occasion?.Name,
                    Active = p.Active,
                    IsAvailable = p.IsAvailable,
                    ImageUrls = p.Images.Select(i => i.ImageUrl).ToList()
                })
                .ToList();

            return result;
        }
        catch (Exception ex)
        {
            _logger.LogError(ex, "Greška prilikom dohvaćanja preporučenih proizvoda za proizvod ID:
{ProductId}", productId);
            return new List<ProductResponse>();
        }
    }

    public async Task<List<ProductCoPurchase>> GetCoPurchaseMapAsync()
    {
        try
        {
            using var context = _contextFactory.CreateDbContext();

            var coPurchases = await context.OrderDetails
                .Include(od => od.Order)
                .AsNoTracking()
                .GroupBy(od => od.OrderId)
                .Select(orderGroup => new
                {
                    OrderId = orderGroup.Key,
                    Products = orderGroup.Select(od => od.ProductId).Where(id => id.HasValue).Select(id
=> id.Value).ToList()
                })
                .ToListAsync();

            var productPairs = new List<(int, int)>();
            foreach (var order in coPurchases)
            {
                for (int i = 0; i < order.Products.Count; i++)
                {
                    for (int j = 0; j < order.Products.Count; j++)
                    {
                        if (i != j)
                        {
                            productPairs.Add((order.Products[i], order.Products[j]));
                        }
                    }
                }
            }

            var result = productPairs
                .GroupBy(pair => pair)
                .Select(g => new ProductCoPurchase
                {
                    ProductId = g.Key.Item1,
                    CoPurchasedProductId = g.Key.Item2,
                    Count = g.Count()
                })
                .ToList();

            return result;
        }
        catch (Exception ex)
        {
            _logger.LogError(ex, "Greška prilikom generiranja mape ko-kupovina");
            return new List<ProductCoPurchase>();
        }
    }

    public async Task RecalculateSimilarityMapAsync()
    {
        try
        {
            _logger.LogInformation("Započinje treniranje ML.NET item-based preporuka");

            // Prvo dohvatimo sve potrebne podatke iz baze u memoriju
            List<RecommendationInput> userProductPurchases;

            // Koristimo poseban scope za dohvaćanje podataka iz baze
            using (var context = _contextFactory.CreateDbContext())
            {
                userProductPurchases = await context.OrderDetails
                    .Include(od => od.Order)
                    .Where(od => od.ProductId.HasValue)
                    .AsNoTracking()
                    .Select(od => new RecommendationInput
                    {
                        userId = od.Order.UserId.ToString(),
                        productId = od.ProductId.Value.ToString(),
                        Label = 1f
                    })
                    .Distinct()
                    .ToListAsync();
            }
            var uniqueUsers = userProductPurchases.Select(p => p.userId).Distinct().Count();
            var uniqueProducts = userProductPurchases.Select(p => p.productId).Distinct().Count();
            var totalPurchases = userProductPurchases.Count;

            _logger.LogInformation("Podaci za treniranje: {TotalPurchases} kupovina, {UniqueUsers}
korisnika, {UniqueProducts} proizvoda",
                totalPurchases, uniqueUsers, uniqueProducts);

            if (uniqueUsers < 2 || uniqueProducts < 2 || totalPurchases < 10)
            {
                _logger.LogWarning("Premalo podataka za treniranje MF modela. Potrebno je barem 2
korisnika, 2 proizvoda i 10 kupovina.");
                _similarityMap.Clear();
                return;
            }

            var density = (double)totalPurchases / (uniqueUsers * uniqueProducts);
            if (density < 0.01) // Manje od 1% popunjenosti matrice
            {
                _logger.LogWarning("Premala gustoća podataka za treniranje MF modela: {Density:P2}.
Koristit ćemo jednostavniju metodu.", density);
            }
            var mlContext = new MLContext();
            var dataView = mlContext.Data.LoadFromEnumerable(userProductPurchases);
            var pipeline = mlContext.Transforms.Conversion
                .MapValueToKey(inputColumnName: nameof(RecommendationInput.userId),
                        outputColumnName: "userIdEncoded")
                .Append(mlContext.Transforms.Conversion
                    .MapValueToKey(inputColumnName: nameof(RecommendationInput.productId),
                        outputColumnName: "productIdEncoded"));
            var transformedData = pipeline.Fit(dataView).Transform(dataView);

            var options = new MatrixFactorizationTrainer.Options
            {
                MatrixColumnIndexColumnName = "userIdEncoded",
                MatrixRowIndexColumnName = "productIdEncoded",
                LabelColumnName = nameof(RecommendationInput.Label),
                NumberOfIterations = 5,
                ApproximationRank = 8,
                Lambda = 0.1,
                LearningRate = 0.01,
                Quiet = true
            };

            // Treniramo model
            var trainer = mlContext.Recommendation().Trainers.MatrixFactorization(options);
            var model = trainer.Fit(transformedData);

            var completeModel = pipeline.Append(trainer);
            var trainedModel = completeModel.Fit(dataView);

            var predictionEngine = mlContext.Model.CreatePredictionEngine<RecommendationInput,
RecommendationPrediction>(trainedModel);

            var newSimilarityMap = new Dictionary<(int, int), double>();
            var productIds = userProductPurchases.Select(p => int.Parse(p.productId)).Distinct().ToList();

            try {
                foreach (var p1 in productIds)
                {
                    foreach (var p2 in productIds)
                    {
                        if (p1 == p2) continue;

                        try {
                            var prediction = predictionEngine.Predict(new RecommendationInput
                            {
                                userId = p1.ToString(),
                                productId = p2.ToString()
                            });

                            // Dodajemo fallback za NaN ili Inf vrijednosti
                            double score = double.IsNaN(prediction.Score) ||
double.IsInfinity(prediction.Score)
                                ? 0.0
                                : prediction.Score;
                score = Math.Max(-5.0, Math.Min(5.0, score));

                newSimilarityMap[(p1, p2)] = score;
              }
              catch (Exception ex) {
                _logger.LogWarning("Greška prilikom predviđanja sličnosti za proizvode {P1} i {P2}: 
{Message}",
                  p1, p2, ex.Message);
                newSimilarityMap[(p1, p2)] = 0.0;
              }
            }
          }
        }
        catch (Exception ex) {
          _logger.LogError(ex, "Greška prilikom izračunavanja sličnosti proizvoda");

          newSimilarityMap = new Dictionary<(int, int), double>();
        }
        _similarityMap = newSimilarityMap;

        _logger.LogInformation("ML.NET sličnosti proizvoda izračunate. Ukupno parova: {Count}", 
_similarityMap.Count);
      }
      catch (Exception ex)
      {
        _logger.LogError(ex, "Greška prilikom izračunavanja ML.NET sličnosti proizvoda");
      }
    }

    public async Task<List<ProductResponse>> GetRecommendedForUserAsync(int userId, int 
maxResults = 10)
    {
      try
      {
        using var context = _contextFactory.CreateDbContext();
        _logger.LogInformation("Dohvaćanje preporuka za korisnika ID: {UserId}", userId);

        var hasOrders = await context.Orders.AnyAsync(o => o.UserId == userId);

        if (!hasOrders)
        {
          _logger.LogInformation("Korisnik ID: {UserId} nema narudžbe, vraćamo featured 
proizvode", userId);
          return await GetFeaturedProductsAsync(maxResults);
        }

        var lastOrders = await context.Orders
          .Where(o => o.UserId == userId)
          .OrderByDescending(o => o.OrderDate)
          .Include(o => o.OrderDetails)
          .Take(3)
          .ToListAsync();

        var recommendedIds = new HashSet<int>();

        foreach (var order in lastOrders)
        {
          foreach (var item in order.OrderDetails.Where(od => od.ProductId.HasValue))
          {
            var recommendations = await GetRecommendedProductsAsync(item.ProductId.Value,
3);
            foreach (var product in recommendations)
              recommendedIds.Add(product.Id);

            if (!recommendedIds.Contains(item.ProductId.Value))
              recommendedIds.Add(item.ProductId.Value);
          }
        }

        var recommendedProducts = await context.Products
          .Where(p => recommendedIds.Contains(p.Id) && p.IsAvailable && p.Active)
          .Include(p => p.Images)
          .Include(p => p.Category)
          .Include(p => p.Occasion)
          .Take(maxResults)
          .ToListAsync();

        _logger.LogInformation("Korisnik ID: {UserId} ima {OrderCount} narudžbi, preporučuje se
{ProductCount} proizvoda", userId, lastOrders.Count, recommendedProducts.Count);

        var result = recommendedProducts.Select(p => new ProductResponse
        {
          Id = p.Id,
          Name = p.Name,
          Description = p.Description,
          Price = p.Price,
          IsNew = p.IsNew,
          IsFeatured = p.IsFeatured,
          CategoryId = p.CategoryId,
          CategoryName = p.Category?.Name,
          OccasionId = p.OccasionId,
          OccasionName = p.Occasion?.Name,
          Active = p.Active,
          IsAvailable = p.IsAvailable,
          ImageUrls = p.Images.Select(i => i.ImageUrl).ToList()
        }).ToList();
```

```
                return result;
            }
            catch (Exception ex)
            {
                _logger.LogError(ex, "Greška prilikom dohvaćanja preporučenih proizvoda za korisnika ID:
{UserId}", userId);
                return new List<ProductResponse>();
            }
        }

        private async Task<List<ProductResponse>> GetFeaturedProductsAsync(int count)
        {
            using var context = _contextFactory.CreateDbContext();

            var featuredProducts = await context.Products
                .Where(p => p.IsAvailable && p.Active && (p.IsFeatured || p.IsNew))
                .Include(p => p.Images)
                .Include(p => p.Category)
                .Include(p => p.Occasion)
                .Take(count)
                .ToListAsync();

            if (featuredProducts.Count == 0)
            {
                featuredProducts = await context.Products
                    .Where(p => p.IsAvailable && p.Active)
                    .Include(p => p.Images)
                    .Include(p => p.Category)
                    .Include(p => p.Occasion)
                    .OrderBy(p => p.Id)
                    .Take(count)
                    .ToListAsync();
            }

            return featuredProducts.Select(p => new ProductResponse
            {
                Id = p.Id,
                Name = p.Name,
                Description = p.Description,
                Price = p.Price,
                IsNew = p.IsNew,
                IsFeatured = p.IsFeatured,
                CategoryId = p.CategoryId,
                CategoryName = p.Category?.Name,
                OccasionId = p.OccasionId,
                OccasionName = p.Occasion?.Name,
                Active = p.Active,
            IsAvailable = p.IsAvailable,
            ImageUrls = p.Images.Select(i => i.ImageUrl).ToList()
        }).ToList();
    }
  }
```

3. Putanja i kod glavne logike kontrolera sistema preporuka

Putanja: FloraApp_RS2\Flora backend\FloraAPI\Controllers\RecommendationsController

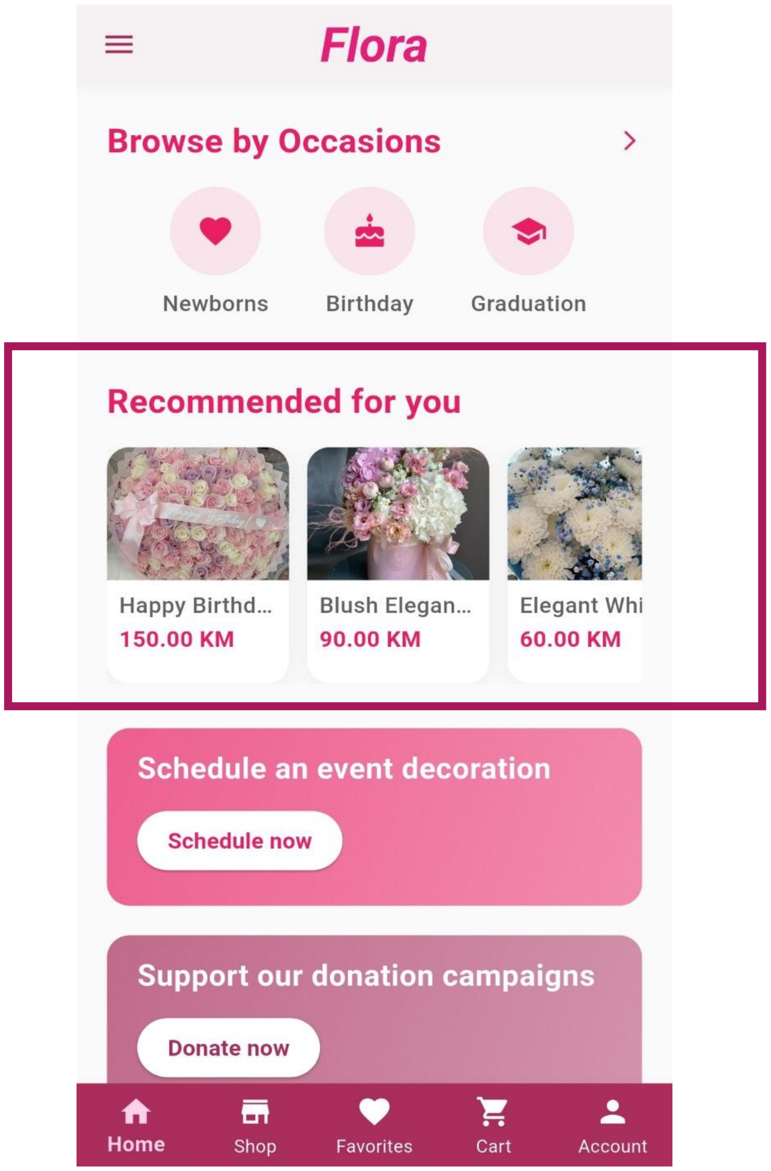
```
 [HttpGet("products/{productId}")]
 public async Task<ActionResult<List<ProductResponse>>> GetProductRecommendations(int
productId, [FromQuery] int topN = 5)
 {
     try
     {
         var recommendations = await
_recommendationService.GetRecommendedProductsAsync(productId, topN);
         _logger.LogInformation("Dohvaćeno {Count} preporuka za proizvod ID: {ProductId}",
recommendations.Count, productId);
         return Ok(recommendations);
     }
     catch (Exception ex)
     {
         _logger.LogError(ex, "Greška prilikom dohvaćanja preporuka za proizvod ID: {ProductId}",
productId);
         return StatusCode(StatusCodes.Status500InternalServerError, "Došlo je do greške prilikom
dohvaćanja preporuka");
     }
 }

 [HttpPost("recalculate")]
 public async Task<IActionResult> RecalculateRecommendations()
 {
     try
     {
         await _recommendationService.RecalculateSimilarityMapAsync();
         return Ok("Izračun sličnosti proizvoda je uspješno pokrenut");
     }
     catch (Exception ex)
     {
          _logger.LogError(ex, "Greška prilikom izračuna sličnosti proizvoda");
          return StatusCode(StatusCodes.Status500InternalServerError, "Došlo je do greške prilikom
izračuna sličnosti proizvoda");
      }
  }
  [HttpGet("co-purchases")]
  public async Task<ActionResult<List<ProductCoPurchase>>> GetCoPurchaseMap()
  {
      try
      {
          var coPurchaseMap = await _recommendationService.GetCoPurchaseMapAsync();
          return Ok(coPurchaseMap);
      }
      catch (Exception ex)
      {
          _logger.LogError(ex, "Greška prilikom dohvaćanja mape ko-kupovina");
          return StatusCode(StatusCodes.Status500InternalServerError, "Došlo je do greške prilikom
dohvaćanja mape ko-kupovina");
      }
  }

  [HttpGet("user/{userId}")]
  public async Task<ActionResult<List<ProductResponse>>> GetRecommendationsForUser(int userId,
[FromQuery] int maxResults = 10)
  {
      try
      {
          var recommendations = await
_recommendationService.GetRecommendedForUserAsync(userId, maxResults);
          _logger.LogInformation("Dohvaćeno {Count} preporuka za korisnika ID: {UserId}",
recommendations.Count, userId);
          return Ok(recommendations);
      }
      catch (Exception ex)
      {
          _logger.LogError(ex, "Greška prilikom dohvaćanja preporuka za korisnika ID: {UserId}", userId);
          return StatusCode(StatusCodes.Status500InternalServerError, "Došlo je do greške prilikom
dohvaćanja preporuka za korisnika");
      }
  }
```

4. Putanja i printscreen iz pokrenute aplikacije gdje se prikazuju preporučeni proizvodi

U mobile aplikaciji (username-mobile, password-test), na početnoj stranici u četvrtoj sekciji se nalaze preporučeni proizvodi


Flora
Browse by Occasions
Newborns
Birthday
Graduation
Recommended for you
Happy Birthd...
150.00 KM
Blush Elegan...
90.00 KM
Elegant Whi
60.00 KM
Schedule an event decoration
Schedule now
Support our donation campaigns
Donate now
Home
Shop
Favorites
Cart
Account